A MODEL FOR REDUCTION OF TRANSPORT-RELATED CO_2 EMISSIONS BY OPTIMIZING INDUSTRIAL WASTE TREATMENT FACILITY LOCATION

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One of the objectives of industrial waste management is to reduce the amount of waste and to ensure its reuse in a way that allows notable improvement of resource efficiency. Location of a waste treatment plant is a strategic issue that require careful logistics system planning. The aim of this article is to create a model for solving the location-allocation problem of waste (i.e. secondary raw materials) treatment facilities, taking into account the territorial distribution, the type, and the quantity of secondary raw materials, the distance between waste-generating industries, as well as the CO_2 emissions from transport of secondary raw materials. The basic principle for defining a mathematical model is minimization of CO_2 emissions from transport-related activities; for this reason, modeling is based on the p median model that has been modified and put within the context of industrial waste management, including CO_2 emissions from transport. The location model is based on common industrial waste streams and CO_2 emissions from vehicles commonly used to transport secondary raw materials from generators to facilities. The verification of the model was performed through a case study that included the region of southeast Serbia. It confirmed usefullness of the proposed model for deciding on optimal locations for new industrial waste treatment plants.

Key words*: CO_2 emissions, transport, optimal location, industrial waste, p median model*

1. Introduction

One of the most important global issues of present times is an evident climate change mostly caused by the greenhouse effect. However, the overall global CO_2 emissions continue to grow [1], even after the United Nations Framework Convention on Climate Change (UNFCCC) entered into force in 1994 with the aim to stabilize the atmospheric concentrations of greenhouse gases at a level that would prevent dangerous anthropogenic impacts on the climate system [2]. In the European Union, CO_2 emissions from the energy sector, industry, agriculture, etc. (with the exeption of transport sector) continue downward trend [3]. However, despite such a tendency, it is expected that the concentration of the most abundant gas from the group of greenhouse gases, CO_2, will remain high in the most of urban areas. Further supporting this claim is the fact that in the 1990-2012 period total

GHG emissions decreased by 18% in the EU, whereas GHG emissions in the transport sector increased by 14% [2,4].

The carbon dioxide emission from transport systems is the subject of various research and analyses. Since the beginning of the 21st century, the issue of emissions generated by freight and service transportation has been recognized by national governments and experts with the aim to raise the awareness of its impact on air pollution. According to the document entitled COM(2016) 501 final A - European Strategy for Low-Emission Mobility [5], the transportation sector, as the main cause of air pollution in cities, was responsible for almost a quarter of EU greenhouse gas emissions in 2014 (70% of these were road transport-related emissions). For this reason, the European Union has set the overall aim – by the middle of this century, all greenhouse gas emissions from transportation activities should be reduced by 60% in comparison to 1990 as a reference year, targeting further decline to their complete reduction [5].

Nowadays, transportation has much greater potential in contributing to the reduction of greenhouse gas emissions than it used to have, which is in line with the commitment undertaken under the Paris Climate Agreement and The 2030 Agenda for Sustainable Development. In line with these challenges, national governments and companies are obliged to take initiatives to transform their transport policies according to sustainability models, with particular reference to the impact of logistics operations on the environment. The European Union has not defined fuel-efficiency standards for trucks yet, nor has it defined the programs for active reduction of CO_2 emissions and carbon emission monitoring programs [5].

According to the Global Carbon Atlas [6] data on emissions from complete combustion of fossil fuels, Serbia emitted 45 Mt of CO_2 in 2015, thus being ranked 64th in the world [6]. On the other hand, according to Petrović et al. [7], Serbia is the fifth carbon-dioxide polluter per capita (6.2 metric tons of CO_2), and the main cause of this pollution is the transport sector as one of the largest GHG emitters (15% of total CO_2 emissions).

By optimizing the transportation system and increasing its performance in terms of minimizing transport costs and raising efficiency of vehicle fuel consumption, total operating costs could be considerably reduced. Environmental issues are an indispensable parameter in logistics network design, considering that the objective is to achieve a balance between profit and environmental impact. In this regard, the focus in the supply chain management concept is shifted from minimizing costs to the balance between costs and environmental impacts [8]. The location of industrial production is one of the cruicial elements for determining the degree of integration of the production system within the environment, as well as for its sustainable operation.

The subject of this research is to ascertain the optimum site location of an industrial waste treatment facility, taking into account the CO_2 emissions accompanying transportation activities. Based on the geographical location and the available quantities of waste generated in the logistics network, it is vital to determine the optimal location of new industrial plants for the efficient supply of secondary raw materials, having in mind the necessity to minimize transport costs and carbon dioxide emissions.

We used the *p median* model, more exactly, the location model tailored to be an expanded version of the *p-median* model. In the nodes of waste generator network, in already defined area, we can locate new industrial facilities (waste treatment plants) which, as input source, use secondary raw material generated as industrial waste from the surrounding industries.

Present-day practice has revealed that transportation costs, along with the availability of secondary raw materials, are extremely significant economic parameters for determining the appropriate locations of new recycling plants. On the other hand, industries generate various quantities of waste that should be disposed of in a safe manner. Waste recycling in the European Union is stimulated by the appropriate regulations, while EU legislation provides exceptional incentives to national governments in their efforts to improve the recycling systems [9-11]. Serbia has not established an integrated industrial waste management system yet, which results in an inefficient waste usage, limited waste recycling capacities and insufficient waste-to-energy conversion [12]. In support of this claim, the data of the Environmental Protection Agency show that, between 2011 and 2016, only about 10% - 15% of the total industrial waste generated in Serbia was sent to treatment [13].

The developed model is a decision support tool that can be applied in planning logistic networks, focusing on the most significant environmental issues related to carbon dioxide emissions from transport and industrial waste management.

2. Location optimization – a brief literature overview

Location problems most often involve finding the optimum number of facilities within the network, taking into account their locations and capacities, in order to minimize transport costs or maximize the quality of service. Input data for solving location problems are the distances between the users who demand a service and the nodes where the facilities can be located [14].

Locating a warehouse, a distribution center, production facilities or a node in a logistics chain is one of the most significant and most complex tasks of supply chain management. Strategic decisions in the logistics chain refer to managerial policies and the development of relevant resources to meet the external requirements in line with organizational goals [15]. In such a decision-making process, locations and the capacities of the main facilities within the system are in focus. Facility location is a strategic issue which is frequently a part of the hierarchical logistic system planning process [15].

A pioneer of location analysis is considered to be Alfred Weber (1909), an economist who proposed a weighted three point model to solve a problem of selecting a location for a factory, with the aim to minimize transport costs from the factory to three groups of raw materials suppliers [16]. There is a large number of publications in the scientific and professional literature dealing with the economic aspects of facility locations in terms of minimizing fixed and operating costs [17]. In accordance with the basic postulates of sustainable development, selection of optimal locations must also entail certain environmental impacts, which in case of logistics systems refer to the emissions of carbon dioxide and other transport-related harmful substances.

Chaabane et al. [18] used the model of mixed integer linear programming as a framework for designing a sustainable supply chain, and proved that efficient carbon management strategies can be helpful in achieving sustainability in terms of savings. Quariguasi Frota Neto et al. [19] managed to apply this concept to the process of designing a sustainable logistic network using the multi-criteria programming method (MOP method). Elhedhli & Merrico [20] integrated the cost of carbon emission into green supply network design. The aim with the developed integrative model was to minimize fixed and variable costs associated with the problem of facility location, taking into consideration that variable costs, apart from transportation costs, imply the costs of transport-related emissions. The results of their research confirmed that the optimal network configuration could be altered by adding carbon emission costs within the supply chain. Introduction of carbon emission cost in the decision-making process trigerred the reduction of the amount of vehicle kilometers traveled. Since the user requirements need to be satisfied, the solution model proposed several distribution centers to reduce travel distances.

Ouhader & El Kyal [21] in their study tried to combine facility location and routing decisions in sustainable urban freight distribution under horizontal collaboration, whereas their approach was based on three objectives: mixed integer linear model which involved minimization of economic costs, minimization of CO_2 emissions and maximization of social impact. The results revealed that such a collaborative approach can reduce CO_2 emissions, transport-related costs and the number of used vehicles, while indirectly reducing traffic congestion in cities.

Xifen et al. [22] developed a multi-objective optimization model to determine the trade-off between economic service and environmental considerations. Uncapacitated facility location problem simultaneously reduces economic costs and CO_2 emissions, and maximizes service reliability by strategically locating facilities within a logistics network. According to Xifen et al., opening more facilities than optimal from an economic point of view would be advantageous in terms of transport-related CO_2 emissions reduction and improvement of reliability of services.

3. The p median model

In this article, modeling is based on site optimization using the p median model approach, tailored to the subject of research and embedded in the context of industrial waste management, including CO_2 emissions from transport. Taking into account that median represents balanced allocation of resources in the observed region, in case of a p median problem, it is necessary to locate one or more facilities within the network in order to minimize average distance (or average travel time or average transport costs) from the facility to the client or vice-versa.

Location optimization with discrete integer variables was first numerically presented in 1964 in the study by Hakimi who assumed that the only solution to the problem were discrete nodes of the graph. Hakimi [23, 24] investigated the shortest weighted distance between p facilities on the n nodes within the network and he named this problem the p median problem [25]. He confirmed mathematicaly that there existed at least one optimal solution by which all p facilities could be located individually on the network nodes, which implies that p optimal facility locations within the network must be exactly in the network nodes [26]. This considerably facilitates the procedure for finding the p median because it is necessary to examine only the locations in the nodes. This type of model is most frequently applied to solve micro-and macro-level problems. An example of macro-level could be determining the location of the warehouse for the receipt of products from various industries with known locations or the warehouses that should distribute the products to the retail network [27].

P median model can be defined using the following parameters: $i = \{1, 2, 3, 4,..., I\}$ the set of candidate locations, $j = \{1, 2, 3, 4,..., J\}$ the set of demand nodes, a_i – demand of customer *I*, *p* – number of facilities and d_{ij} – distance between demand node *i* and site *j*.

Two decision variables are introduced x_{ij} i X_j:

- $x_{ij} = 1$, if demand at node *i* is served by a facility at site *j*; otherwise $x_{ij} = 0$,
- $X_j = 1$, if a facility is located at site *j*; otherwise $X_j = 0$.

While locating the *p* facility, we aim to minimize the total distance travelled between the facilities and the customers, so the p median problem can be formulated using the criterion function:

$$\min F = \sum_{j \in J} \sum_{i \in I} a_i d_{ij} x_{ij} \quad (1)$$

S.t.

$$\sum_{j \in J} x_{ij} = 1 \quad \forall i \in I \quad (2)$$

$$\sum_{j \in J} X_j = p \quad (3)$$

$$X_j \geq x_{ij} \quad \forall i \in I, \forall j \in J; i \neq j \quad (4)$$

$$X_j \in \{0,1\} \quad \forall j \in J \quad (5)$$

$$x_{ij} \in \{0,1\} \quad \forall i \in I \ \forall j \in J \quad (6)$$

A defined criterion (1) tends to minimize the total distance travelled between the facilities and the customers. In expression (1), *I* and *J* are the upper limits to which the integers *i* and *j* can vary, and in both cases it is the number *n* since each of the *n* locations is simultaneously a potential candidate for an optimal solution. The constraint (2) allows each node to be serviced by a single facility. The constraint (3) defines *p* number of facilities that should be located, and it represents the physical limitation concerning the number of facilities, but at the same time it requires that all *p* locations have to be allocated. The constraint (4) is a controlling factor that permits customer allocation to the located facilities only (allocation variable). Constraints (5) and (6) reflect the binary character of decisions to be made if this model is used.

4. Methodology applied to develop a CO_2 emission – based location selection model

The model is used to select the location of one or more facilities for industrial waste treatment within the existing road network, capable to accept the annual waste generation in a defined geographical area. The first steps were to define a geographical region of interest, to identify relevant industrial entities whitin it, and the amounts of waste they generated (in terms of waste type, marked by EU six-digit code). Afterwards, a secondary database of the location model was designed. The model database comprised master data about the facility (the waste generator), for identification and precise geographic location (e.g. by Google Maps).

The data on industrial entities and the quantities of waste generated can be found in the database of the National Register of Polluters [28], which is available on the website of the Environmental Protection Agency of the Ministry of Environmental Protection of the Republic of Serbia. In accordance with the Law on Waste Management ("Official Gazette of the Republic of Serbia", No. 36/2009, 88/2010 and 14/2016) and the relevant bylaws, the companies have to report regularly (once a year, for the previous year) on the quantities of generated wastes (by entering waste type and corresponding six-digit waste code) [29].

For modelling we used a tailor-made version of the p median model, i.e. the expansion of the p median model that focus on the reduction of CO_2 emissions from transport. The objective of the modelled problem was to determine the optimal location of the waste treatment plant for known industrial waste streams, as well as to assign the customers to each of located facilities, in order to minimize carbon dioxide emissions from transportation. Estimating fuel consumption and CO_2 emissions from transport requires complex calculations and often approximations due to difficulties when quantifying certain variables, such as weather conditions, traffic congestion, various driving styles, etc [21]. There are different methods used to calculate fuel consumption and CO_2 emissions from road transport depending on numerous parameters; however, the choice of the method depends on the data available. In this paper, we used the COPERT IV [30] model to calculate CO_2 emissions, based on average fuel consumption that depends on vehicle category, various technologies and fuel type used for the transport of secondary raw materials. COPERT IV is a model and a software tool designed to calculate air pollutant emissions from road transport and is an integral part of the European Union guidelines on maximum emissions at the national level. According to recomendations provided by consulted experts for transport of secondary raw materials (freight transport), heavy freight vehicles weighing up to 32 tons were taken in consideration. Since the Tier 2 method within COPERT IV model estimates fuel consumption for different vehicle categories, it was used for the purpose in this study (namely, for estimation of heavy goods vehicles fuel consumption, EURO 1 technology and latter). Based on the fuel consumption of heavy goods vehicles within an observed timeframe, and hydrogen and cyrbon atoms ratio of diesel, we used Tier 3 method to calculate CO_2 emissions. The structure and the algorithm of the proposed location model can be described by the following steps, shown in Fig. 1 [14].

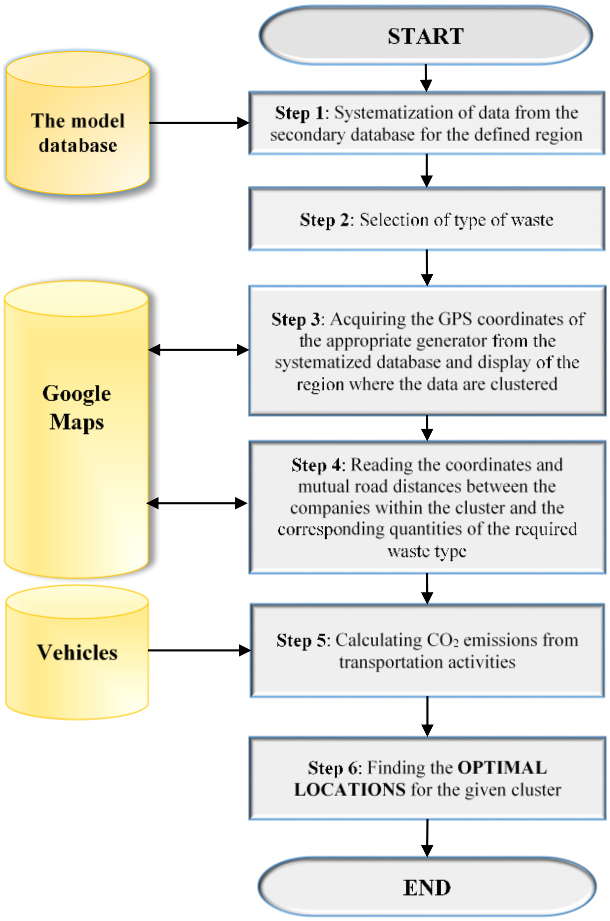

Figure 1. The algorithm of the proposed location model

At the beginning of the diagram flow, Step 1 and Step 2 present the systematization of data from the secondary database for the defined region and the selection of type of waste needed for treatment and reuse. In the next stage, the address (and/or GPS coordinates) of the appropriate generator (by entering the six-digit code for waste) from the systematized database is acquired and the region (in Google Maps), where the data are clustered (companies that generate cetain type of waste) is displayed. The fourth step refers to reading the coordinates and mutual road distances between the companies within the cluster (by using Google Maps) and the corresponding quantities of the required waste type. Further, the calculation of CO_2 emissions from transportation activities based on average consumption and fuel type used is done by the application of COPERT IV method. Finally, the optimal locations for the given cluster, based on the amounts of waste generated in the companies, road distances and CO_2 emissions from transport activities, are spotted.

5. Formulation of proposed location optimization problem and the model description

The proposed location model is an expanded version (a modification) of the p median model, where the modification refers to taking into account CO_2 emissions from road transport by heavy vehicles used to supply secondary raw materials. The modeled problem is recognized as a single-criterion, discrete, static, location-allocation network problem.

The parameters of the discussed model are: $i = 1, 2, 3, 4, \ldots I$ – the set of demand nodes where industries are located; $j = 1, 2, 3, 4, \ldots J$ – the set of nodes where it is possible to locate new industrial consumers of secondary materials or waste treatment plants; a_i – the quantities of waste generated in the node i [t]; w – the carrying capacity for a vehicle [t]; e_{vf} – the CO_2 emissions of a fully loaded vehicle [kg/km]; e_{ve} – the CO_2 emissions of an empty vehicle [kg/km]; p – the number of facilities to be located in the network; d_{ij} – the distance between the node i and the node j [km].

The two binary location variables were introduced to facilitate calculation: X_j takes a value of one if the waste treatment plants are located in the node j, otherwise its value is zero; x_{ij} takes a value one if the generated quantity of waste from the industry i has a destination in the node j, otherwise the value is zero. Mathematical model of the observed location problem was defined as follows [22]:

$$\min F = \sum_{j \in J} \sum_{i \in I} d_{ij} \left[\left(\varepsilon_{vf} - \varepsilon_{ve} \right) \frac{a_i}{w} + \varepsilon_{ve} \left\lceil \frac{a_i}{w} \right\rceil \right] x_{ij} \tag{7}$$

S.t.

$$\sum_{j \in J} x_{ij} = 1 \quad \forall i \in I \tag{8}$$

$$\sum_{j \in J} X_j = p \tag{9}$$

$$X_j \geq x_{ij} \quad \forall i \in I, \forall j \in J; i \neq j \tag{10}$$

$$X_j \in \{0,1\} \quad \forall j \in J \tag{11}$$

$$x_{ij} \in \{0,1\} \quad \forall i \in I \ \ \forall j \in J \tag{12}$$

The objective function (7) minimizes CO_2 emissions from transportation. Constraint set (8) through (12) are identical to (2) through (6) of the p-median problem (Section 3.). For the model observed, the constraint (8) states that the generated amount of waste in each node (industry) can be taken from a single treatment plant only. The constraint (9) is a physical constraint that refers to the number of plants to be located, while the constraint (10) permits the allocation of waste generators to the located treatment facilities only. Constraints (11) i (12) refer to the binary nature of decisions to be made using this model. To solve the problem of this study, we used a Greedy heuristic algorithm.

6. The location optimization model testing – a case study

To test the described model, we assumed there was a need to construct a new industrial facility which would consume waste tyres. The location optimization model was applied to the region of South-East Serbia, for which we used the systematized database of industries/waste generators with corresponding quantities of industrial waste for the reference year 2016. The waste generator database is presented in Tab. 1. The six-digit code for waste tyres in the European Waste Catalogue (EWC) is 16 01 03. In the region, we idenified 18 industries with the same waste code, so $i = 1, 2, ..., 18$. A set of nodes where it is possible to locate new industrial waste treatment facilities is $j = 1, 2, ... 18$. The demand of each customer a_i, as shown in Tab. 1, represents the amount of generated waste [t] in the node i.

Table 1. Database of waste generators for EWC 16 01 03 (waste tyres)

No of location	Facility located in	Geographic coordinates of the generator	Industrial sector of the waste generator	Amount of waste a_i [t]
L_1.	Bor	44°04'54.8"N 22°05'52.3"E	Mining	493.2
L_2.	Bor	44°03'33.7"N 22°06'01.7"E	Copper production	58.7
L_3.	Bor	44°03'40.6"N 22°06'12.6"E	Road freight transport	5.5
L_4.	Bor	44°03'23.9"N 22°07'14.4"E	Road passenger transportation	3.8
L_5.	Majdanpek	44°24'19.3"N 21°56'04.5"E	Exploration and exploitation of ores	246.9
L_6.	Majdanpek	44°25'19.1"N 21°56'56.8"E	Non-hazardous waste treatment	944.5
L_7.	Kostolac	44°43'17.8"N 21°10'30.5"E	Road freight transport	12.8
L_8	Požarevac	44°37'00.0"N 21°11'00.0"E	Road construction	7.8
L_9.	Niš	43°19'21.5"N 21°54'43.7"E	Road passenger transportation	36.7
L_{10}.	Niš	43°19'07.3"N 21°53'55.4"E	Road construction	21.4
L_{11}.	Niš	43°18'54.7"N 21°48'27.0"E	Manufacture of rubber products	43.6
L_{12}.	Niš	43°19'32.6"N 21°57'50.5"E	Construction	8.3
L_{13}.	Vranje	42°32'60.0"N 21°54'00.0"E	Road passenger transportation	12.2
L_{14}.	Pirot	43°10'28.9"N 22°34'43.2"E	Rubber production	2376.3
L_{15}.	Smederevo	44°37'01.3"N 20°58'06.7"E	Reuse of materials	13.8
L_{16}.	Smederevo	44°40'00.7"N 20°55'43.4"E	Road passenger transportation	10.9

No of location	Facility located in	Geographic coordinates of the generator	Industrial sector of the waste generator	Amount of waste a_i [t]
L_{17}.	Smederevska Palanka	44°22'45.3"N 20°57'09.5"E	Road passenger transportation	118.9
L_{18}.	Blace	43°17'49.4"N 21°17'02.7"E	Manufacture of rubber products	62.0

Source: National Register of Polluters, EPA, Ministry of Environment, Serbia

Tab. 2 shows mutual road distances between all waste generators, i.e. road distances between the industries (*i*) and the nodes where it is possible to locate new industrial waste treatment facilities (*j*), d_{ij} [km]. A new waste treatment facility was intended to be planted at the locations where waste generators operate, having in mind the efficient supply (availability) of secondary raw materials, and current waste management legislation. This idea was further supported by one of the basic principles defined by the Law on Waste Management, the so-called principle of proximity and regional approach to waste management, which stipulates that "waste should be treated or disposed of as close as possible to the place of its origin" [29]. The lengths of the network branches, representing road distances between all waste generators, are defined using Google Maps on-line tool.

The truck considered was fully loaded 32 tons vehicle; the CO_2 emissions for a fully loaded vehicle were e_{vf} = 0.7875 [kg/km], whereas the emissions of an empty vehicle were e_{ve} = 0.6589 [kg/km]. MATLAB Version 7.10 (R2010a) was used for computation, and the results are shown in Tab. 2.

Table 2. Road distances between the industry (*i*) and the nodes where it is possible to locate new industrial waste treatment plants (*j*), d_{ij} [km]

Number of location Li																	
L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}
0	3	2.8	5	63	64	146	132	126	130	139	120	274	132	151	157	146	168
3	0	1.8	3.1	66	65	145	131	125	129	138	119	273	131	150	156	145	167
2.8	1.8	0	1.8	70	69	144	130	123	127	137	117	271	129	148	154	144	166
5	3.1	1.8	0	69	68	143	131	122	126	136	116	270	130	149	156	145	167
63	66	70	69	0	5.5	116	104	178	182	192	173	300	184	121	128	130	235
64	65	69	68	5.5	0	115	103	177	181	191	172	299	183	120	127	129	234
146	145	144	143	131	115	0	13	205	206	204	210	312	271	32	39	55	207
132	131	130	131	104	103	13	0	194	195	192	199	300	260	20	27	43	195
126	125	123	122	178	177	205	194	0	2.4	10	5.5	125	68	185	191	163	68
130	129	127	126	182	181	206	195	2.4	0	8	7	114	71	185	191	163	63
139	138	137	136	192	191	204	192	10	8	0	14	116	83	183	189	161	51
120	119	117	116	173	172	210	199	5.5	7	14	0	129	63	189	195	167	72
274	273	271	270	300	299	312	300	125	114	116	129	0	131	291	296	268	148
132	131	129	130	184	183	271	260	68	71	83	63	131	0	250	256	227	133
151	150	148	149	121	120	32	20	185	185	183	189	291	250	0	6.6	30	185
157	156	154	156	128	127	39	27	191	191	189	195	296	256	6.6	0	36	190
146	145	144	145	130	129	55	43	163	163	161	167	268	227	30	36	0	163
168	167	166	167	235	234	207	195	68	63	51	72	148	133	185	90	163	0

7. The results and discussion

The results of the location model applied in the described case study show that the optimal location for the waste treatment facility was the site L_{14}, with corresponding CO_2 emission of 22,904.6114 [kg]. Hereby, three optimal locations (p=3) were chosen and the industries were allocated to the optimal locations, as shown in Tab. 3.

Table 3. Best solution optimized facility location

Optimal facility location	Allocation of industrial customers to observed facility	CO_2 emissions [kg]
L_{14}	L_9, L_{10}, L_{11}, L_{12}, L_{13}, L_{14}, L_{18}	22.9046×10^3
L_6	L_5, L_6, L_7, L_8, L_{15}, L_{16}, L_{17}	
L_1	L_1, L_2, L_3, L_4	

Fig. 2 provides a graphical presentation of the results of location optimization, where three clusters with three optimal locations have been defined and the industries (waste generators) have been allocated to the corresponding optimal locations. Google Maps were used for graphical representation.

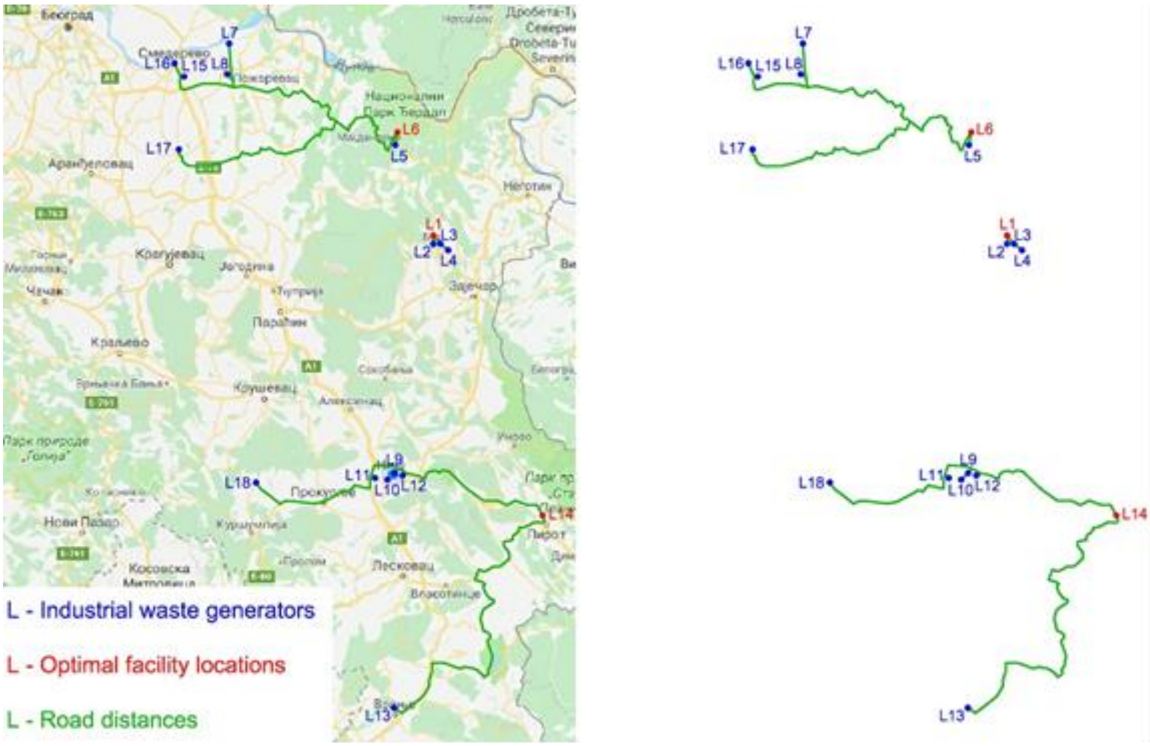

Figure 2. Graphical representation of the results of the location model applied

From the results obtained, it can be concluded that the defined mathematical model is a helpful tool to support strategic decision making, and a tool that facilitates reduction of CO_2 emissions from transport-related activities.

8. Conclusion

Resource depletion is an important motivation factor for finding effective solutions to utilize recycled materials and to optimize supply chains. Related logistic problems have become one of the greatest challenges of modern waste management. Optimizing the flow of products and waste materials that could be reused became an important strategic approach in modern environmental protection. The very first step towards optimizing a supply chain is to determine the optimal location of one or more facilities within it.

The aim of this paper was to describe a model created for solving the location problem of the waste treatment facility in a region of South-East Serbia, taking into consideration possibilities to reduce CO_2 emissions from transport, i.e. supply of reusable materials from industrial waste generators to the treatment facility. The mathematical model of p median was modified, and the quantities of generated wastes in the supply chain, as well as the emissions from transport vehicles were also considered. The emissions for a loaded, and an empty heavy fright vehicle were calculated using COPERT IV model. In order to verify the model, we analyzed a territorial area of the South-East Serbia which involved waste generators, assuming a need to locate the facility for waste tyres and rubber treatment. Three optimal locations (L_{14}, L_6, L_1) were determined in accordance with input data, and waste generators were allocated to them. The implemented location model is capable to optimize any required number of facility locations, as well as to allocate available secondary resources to chosen facilities. The results of the verification reveal the applicability of the model for decision-making, even in cases with larger number of industrial customers in the supply chain.

The developed location model is a decision support tool that can be applied in logistics network planning, focusing on the most relevant environmental issues, one of which is carbon dioxide emission from transport and industrial waste management. On the one hand, this approach allows the companies to improve environmental performance of their supply chains, but on the other it supports the fulfillment of national and international targets regarding transport-related CO_2 emissions.

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