Example for application of the PTV VISION VISUM software tool for the calculation of noise and emissions from motor traffic

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A R T I C L E   I N F O

A B S T R A C T

Today, pollution is a worldwide problem. Pollution is a result due to the rapid growth of civilization and the number of motor vehicles. It causes deterioration and poisoning of the environment, including air, water and soil, and poses a serious threat to the human health. With the process of urbanization, the need for mobility over short and long distances with use of motored vehicles also grows. In addition to the forecast of transport demand for a certain period of time, there are also software tools that allow the calculation and forecast of the percentage of harmful emissions and noise caused by traffic. In this paper, the module that contains the software tool Visum for the environment for the city of Prilep, North Macedonia will be presented.

1. Introduction

In today's world, there are a large number of software tools and packages that facilitate the work of engineers. They are especially important for traffic engineers whose work would be unimaginable without computer precision. With the development of information and computer technologies, traffic engineers have found their mitigating circumstance with the use of software. There are several tools for analysis, planning, calculation, and forecasting, which can be used at any time if the appropriate input data is available. From simulations of traffic flows, traffic accidents, and transport demands for certain areas, to collection and analysis of transport data. PTV VISION VISUM, is the world-leading software which gives the users many modules that supplement the numerous functions of this software, such as the module considered in this paper, the environment module. The pollution problem required various analyzes and papers are constantly being made to reduce it, offering various measures and solutions. Thus, this software offers a module that allows, with the help of an already installed base for a certain city (in this example, the city of Prilep, North Macedonia), the road network, intersections, and zones to be

drawn. The four-level model is created, matrices for the paths, in the section for the calculation of modal sizes in addition to the generation of trips, the distribution, the skim matrix and the prescriptions of the trips are created as well as the module for calculation of the harmful emissions caused by the transport and noise. The aim and task of this paper is to present the module and output results.[1] Thankfully to todays large number of software, it is possible to calculate and analyze the harmful emissions and noise caused by traffic, but with the application of the PTV Vision VISUM software tool and the environment module, not many papers with this or similar content have been produced [10 - 12].

2. PTV VISION VISUM Software Tool

In more developed countries, traffic forecasts are made with this modern software tool. It would be unimaginable to create a traffic forecast without a computer tool. Thus, in addition to facilitating the work of traffic engineers, output results are obtained, i.e. the benefits and losses, if a new type of traffic control is introduced, without conducting trial tests directly in the field.

The macroscopic traffic model PTV Visum is the world's leading traffic analysis, forecasting and data management software that reliably models all road users and their interactions. In VISUM, transport demand can be modeled, as well as its forecasts which can be made for neighborhoods in urban areas, cities, regions, and countries. The continuous increase in traffic demand leads to an increase in traffic flows resulting in traffic jams, increased environmental pollution and increased risk of accidents. This software uses the four-step model:

1. Trip generation models - total number of trips produced or attracted by the traffic zone;
2. Travel distribution models - between each pair of zones of the observed area;
3. Models of distribution of trips by mode of transport - distribution of the total number of trips between each pair of zones by mode of transport;
4. Flow distribution models - assigning trips to the network (network included assignment) - assigning all source-destination trips to the observed traffic network, that is, its elements.

In the part where we do the procedure for the calculation of modal sizes, in addition to defining the generation, distribution, rewriting of trips, we can also define an additional module that calculates environmental impacts such as noise and pollutants caused by motorized private transport. [2]

3. Traffic as a source of air pollution

The pollution of air means the degradation of air quality which can have a harmful effect on living organisms as well as certain objects.

Pollution is a serious issue nowadays that civilization is facing, and it is due to the very rapid progress in several areas of our life such as industries, transport, mining, construction, agriculture, etc. Humans are the only creatures on Earth who move through all spheres of the natural environment on the surface of our planet. That is why the human is the biggest factor that participates in the pollution of the environment. Pollutants can be in solid particles, liquid droplets or gases. Air pollution can be natural, and through various human activities (anthropogenic sources). Pollutants of natural origin are: volcanoes, fire, soil dust, and anthropogenic sources include the following sources of air pollution:
1. Stationary sources are chimneys of power plants, factories and waste incinerators, as well as furnaces and other types of devices that burn fuel.
2. Mobile sources are all motor vehicles which are powered by a combust engine which is fueled by gas, including airplanes, automobiles, ships etc.

The term traffic refers to the movement of people, goods, signals and information from one place to another. Because of this, the need to develop a better and more modern way of meeting the needs from the aspect of transport has arisen. With the increase in the number of motor vehicles, there is an increase in gas pollution, as well as an increase in land for the construction of new roads, bridges, tunnels that will enable a flawless and fast way of transportation. But all this affects the environment. Regardless of whether it is road, water or air traffic, they all pollute the atmospheric air in some way with a large amount of smoke, dust, carbon monoxide, nitrogen and other harmful gases. Traffic is everything that has a large share in environmental pollution, and it has a particularly degrading effect in urban areas. Motorization can lead up to 60% of total pollution. In urban areas, the main emitters are passenger vehicles, that is, internal combustion engines used in various vehicles. Regardless of the degree of combustion, internal combustion engines emit polluting substances that pose a potential danger to the environment and human health, and at the same time threaten traffic safety. The vehicle fleet has increased by 15% in the last decade, the share of passenger cars with a diesel engine has doubled in just 5 years, while most of them do not have a device for treating non-degradable particles in the exhaust - filters for smoke particles, four out of five vehicles are older than 10 years, and maybe already 20, driving through cities at highway speeds are enough reasons for cars to be one of the factors for air pollution.[3]

Figure 1. Stationary and mobile sources of air pollution
Source: (https://akademik.mk)

3.1 Types of emissions caused by traffic

If we take into account that our entire society is based on the principle that "every person should own a vehicle and use it often", it is logical that traffic is most developed in big cities where the air is mostly polluted. Air pollution is caused by improper or incomplete combustion of fuel. Air pollution is caused by the by-products of the combustion process:
• exhaust emissions,
• evaporative emissions.

Exhaust emissions - are created when fuel and air burn in the engine and are emitted when the vehicle is moving, during a cold start, they are usually controlled and purified by installing catalytic converters, filters...

Evaporative emissions – in vehicles, evaporative emissions are emitted from the fuel tank, the fuel supply and the fuel mixture ignition system. It represents a much smaller percentage in relation to exhaust emissions.

They are emitted during movement, during cooling, during the day and when the vehicle is not moving, i.e. it is not lit, due to the high temperature it evaporates, when filling with fuel, paint, tires and other rubber materials, means for washing the windows. Air pollution from the vehicle originates from several factors, of which the main part 95-99% belongs to the exhaust gases, and the rest comes from the crankcase, carburetor and fuel tank. About 280 pollutants are found in the exhaust gases of internal combustion engines alone. It is known that from 1 liter of gasoline, about 10 m^2 of harmful gases are obtained, which have a negative effect on the human body. Internal combustion engines emit a large number of gases such as carbon monoxide, nitrogen, sulfur, carbon dioxide during the process of releasing exhaust and evaporative emissions. In Macedonia, leaded gasoline has been phased out, but instead, benzene and aromatics are used, which emit pure gasoline and dangerous compounds into the atmosphere. Vehicles emit a large number of emissions that have a negative impact on the environment, namely carbon monoxide, nitrogen oxides, sulfur and cause great consequences, smog, acid rain, ozone formation, particles, serious diseases and death in humans (Shown in Figure 3.).[4]
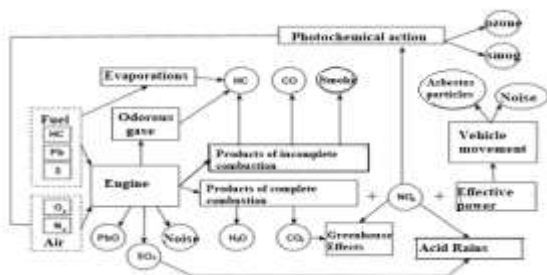

Figure 2. Vehicle Emissions
Source: (Created by the student)

Figure 3. Consequences of pollution
Source: (https://hindustannewshub.com/)

4. Pollution in Macedonia

Macedonia is not the first country in the world to face air pollution and should use good practices from other countries to deal with this problem. The air in Macedonia is alarmingly polluted. This is indicated by the measuring stations, which register pollution that is several times higher than allowed almost every day. Due to the fact that the air is polluted with dangerous particles, the inhabitants of several Macedonian municipalities breathe on "gills".[5] The analysis of the World Bank shows that the highly industrialized centers significantly contribute to the poor air quality. Industry, old vehicles, motor fuels in traffic and heating with wood and coal are the most common pollutants. The situation worsens especially in winter due to the absence of a gas pipeline system, which forces the households to warm themselves whit a fireplace fueled by wood. Old vehicles also pollute a lot. Although Euro 4 standards are in force, Macedonia is flooded with old vehicles. Because of all this, the bigger cities in Macedonia in winter are under "white curtains" of dirty air. Over 90% of the air pollution in the cities is due to the emission of particles by the large number of older vehicles together with the maintenance of the poor, inadequate infrastructure and the low quality of the fuel. The problems of air pollution are more pronounced in urban areas. The state of the traffic systems in our cities is specific because it largely does not correspond to the basic principles that are closely related to the ecological modalities in modern cities. It affects the connection of separate parts of the city, because by reducing the speed of motor vehicles on city streets, more fuel is consumed and more quantities of polluting substances are released. Pollution from vehicles depends on the type and number of motor vehicles.[6]

5. Module in the software tool VISUM environment –noise and pollutants

The PTV Visum Environment add-on module calculates environmental impacts such as noise and pollutants caused by motorized private transport. The results are shown in graphs and tables. The following models are available for calculating environmental impacts:

❖ Calculation of noise emission levels according to 'RLS-90'
❖ Calculation of air pollution emissions in accordance with the emission factors of the Swiss Federal Office for the Environment.

With the help of this software, it is possible to determine how the flow of vehicles affects the environment. It is possible to determine the noise level of a given section, the level of nitrogen oxides, sulfur dioxide, carbon monoxide, hydrocarbons.

The increased frequency of traffic, in addition to reducing the quality of life, negative consequences on people's health, the biggest problem in the global framework is air pollution. Pollution is perhaps the most serious problem facing our civilization. Most often it is caused by human activities such as mining, construction, transport, industry, and agriculture. The exponential growth of human activities, the development of technology, and the greater presence of various types of polluting substances in the air that have a negative effect on human health, lead to damage in the natural ecosystems, reduction of stratospheric ozone, visible degradation of the biosphere as well as modification of the weather and the climate. A large number of pollutants are present in the air in urban and industrial environments, which can be classified in different ways. By determining the degree of pollution, it is necessary to introduce certain measures to reduce pollution and improve the quality of life. By introducing environmentally friendly vehicles, setting up protective barriers to reduce noise, planting greenery, methane vehicles, electric vehicles and other measures.[7]

The procedure for determining the emissions caused by the current is determined as follows: Calculate - Procedure sequence - Create - Assignment - PrT assignment - OK. [8]

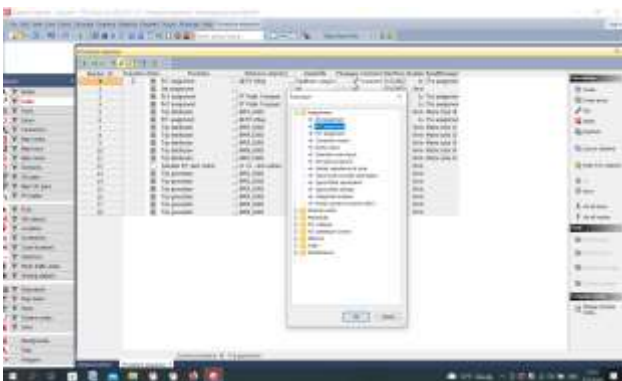In the Reference object(s) field, select all the proposed uses and select OK. This step is shown in Figure 4.

Figure 4. Selection of the PrT assignments tool for the calculation of vehicle emissions
Source: (Created by the student in Visum software)

Figure 5 shows the procedure for reading the calculated values for the caused emissions from the vehicles. At the beginning, we select to be active Link, select which section we want to see the moved sizes, Edit Link – Environment.[8]
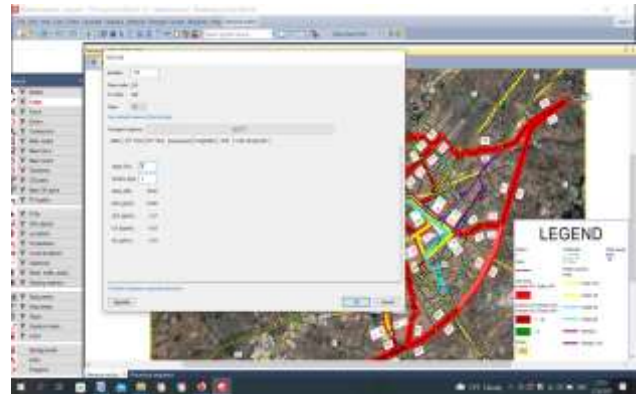

Figure 5. Reading of the calculated values for the caused emissions from the vehicles
Source: (Created by the student in Visum software)

6. Measures to reduce pollution

The following are some of the measures that can be applied when the level of pollution is high:

- To prohibit motorized traffic in the central city area and in other parts of the city (where it will be estimated that the ban will have an effect on demotivating the use of private vehicles) except for public transport and special vehicles (police, fire, first aid);

- To make a strict mode of delivery of goods by trucks, the non-compliance of which will be sanctioned.

- To prohibit the use of cars for a standard lower than EURO 4 and for vehicles with a diesel engine.

- To drive cars on the even-odd principle.

- To take measures that would demotivate the transportation of one person in one car or incentive measures that would motivate car-sharing.

- To have a strict attitude towards illegally parked vehicles on pedestrian and bicycle paths (parking everywhere, "next to the door", "5 minutes away" is one of the main demotivators of walking and cycling, which are non-polluting modes of transport).

- To introduce free public transport.

- To distribute protective masks with appropriate standards that protect against PM 10 the particles.

- To expand pedestrian zones in the centers of all cities.

- Instead of widening streets for car traffic, which attracts new vehicles, implement "street diets". Street diet means reducing the number of vehicle lanes on a street or keeping the same number of vehicle lanes, but narrowing them. In both cases, the excess space is allocated to non-polluting transport, thus increasing safety, and reducing pollution.

- To increase the eco-standards for the import of vehicles.
- To introduce different rewards for employees who come to work by bicycle, on foot or by bus.
- To install catalytic converters, filters.
- Awareness is key.[9]

7. Conclusion

Air pollution is a problem throughout the EU (European Union) and causes 40 deaths every 100 years. The EU (European Union) places importance on air quality in each country. In general, the pollution slowly poisons the air and does not cause health consequences. Measures are taken to prevent failure, but it is still mostly due to the human factor. There will be nothing better than the day when we can open our windows and we can see clean and fresh air. Every institution, every enterprise, every special one, needs to conscientiously and proudly show that it is doing something good for our environment. Traffic is the main cause, the large number of motor vehicles that emit large gases, the use of space that instead of being chosen for greenery that will lead to the end of pollution, they dedicate it to the construction of others, bridges, tunnels.

All even motor vehicles are unique in the air transport way that will happen, when public transport, walking, cycling will be used then we can talk about the transfer of polluted air. We should all be aware of what we suffer from the unconscious or, on the other hand, conscious destruction and exploitation of the natural resources available to the environment. They feel the consequences of environmental and air pollution. Awareness of the value of the environment is fundamental for something to be preserved and improved. It is formed under the influence of many factors such as: culture, upbringing, education, the value system of the society in which we live, etc. In this process, the media, which convey the information to the users, are also of great importance.

There are several software and quantities that can be used to indirectly perceive the consequences that arise from the use of motor vehicles. Thus, the software tool PTV VISION VISUM offers the possibility to perform a forecast of transport regions on the territory of the city, the state, for a certain period of time and to review the reviews of emissions and noise that will occur with an increase in demand. Figure 4 shows the open noise in decibels (dB), reviewed emissions for NOx, SO2, CO, HC expressed in grams/kilometer (g/km), for the city of Prilep, on a section of the A3 highway. By applying this software tool and the environment module, we get real output results for the level of harmful emissions and caused noise in a given territory that is

being analyzed, based on real collected data. Based on the published results we can provide practical solutions such as the installation of barriers, greenery to reduce noise, the replacement of paved older streets with asphalt, generally better traffic management and reducing speed limits to 30 kilometers per hour, cycling, using electric vehicles, application of different charges: road charges, parking charges, fuel fees, tariffs in public transport and land use planning, etc.

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