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Air pollution reduction with ıntelligent transportation systems: Dilovası scenario

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Abstract. Traffic management is one of the main application areas for ITS (Intelligent Transportation Systems). This management begins with the collection of movements and data affecting the route. Ultimately, the data will be used for information access systems. This study is one of the study areas of "Scenario for Reducing the Dilovasi Air Pollution with the ITS Application" which is supported by TUBITAK within the COST (European Cooperation in Scientific and Technology) Program. Within the scope of "Scenario for Reducing Air Pollution with the Intelligent Transport System Application" work package, an alternative route design was made to TEM (Trans European Motorway). Air pollution from road traffic has the highest share in air pollution caused by transportation. Dilovası, which is designated as a sample region in this study, is a region where high industrialization and the main arteries connecting Istanbul metropolises to other cities pass through the city center, where air pollution is intense and the effects caused by this pollution are seen intensively. Transfer to north of vehicle traffic will reduce the air pollution caused by transport to the region. The variable values of air pollution make it possible to use the newly designed road as an alternative way. It is planned that the TEM will be closed and the alternative route will be mandatory if air pollution reaches the value that will affect human health. There are two air pollution measuring stations in the Dilovası region. These stations measure air pollution and produce standardized data. If the data received from the stations are evaluated as part of the ITS designed in the project and the values are not at the desired level, the decision to close the current route is given by the system. This decision must be forwarded to the drivers on the road approaching the area. Among the methods used are many applications such as variable message boards, radios, internet and smart phone systems. The aim is that drivers should turn to an alternative route and should be informed that the current route is closed. In addition, it is important to establish a working system based on meteorological conditions like air pollution in its application. For example, the prevailing wind in the region is known to blow from the north-northeast direction and carry pollution to the region. Therefore, it will be ensured that the emissions from the highway will be transported out of the region by an alternative route.

Keywords: Air pollution, Intelligent transportation systems, Traffic, Transportation

1. Introduction

The highway is a type of transportation that has an important impact on climate change as well as air pollution. The main purpose of this study is to provide a method to prevent the effect of road transport and emission pollution on smart transportation systems. Road transport, which is one of the stakeholders

of environmental pollution causing climate change, aims to provide a method to prevent the emission-related pollution impact by smart transportation systems. The National Action Plan Document on Climate Change states that the Road Sector is one of the sectors causing the highest greenhouse gas emissions among the Transportation sectors. It is emphasized that the share of urban transport in measured emissions is high. These data point to Intelligent Transportation Systems in many areas and in reducing greenhouse gas impacts on highways. Smart Transportation Systems not only facilitate transportation in many areas, but also a strategy to develop useful products and practices to prevent air pollution and reduce greenhouse emissions. Transportation, which has an important share in air pollution, causes environmental pollution during construction of transportation roads, production of motor vehicles, destruction of vehicles and operation of roads. This study is one of the research areas titled Dil Dilovası Air Pollution Mitigation Scenario with Intelligent Transportation System Application ((Project No: 117Y298) supported by TUBITAK within the scope of COST (European Cooperation in the Field of Scientific and Technical Research) Program. Within the scope of the Intelligent Transportation System Scenario for Air Pollution Reduction ”work package, an alternative route design to TEM highway was designed. In this context, it is aimed to benefit from smart transportation systems in order to minimize air pollution during the operation of road transport. Dilovası was chosen as the sample section and an alternative road crossing search was made for the existing roads and it was suggested to use smart transportation system for the transportation of traffic.

2. Air Pollution and Transportation

Air pollution is defined as the presence of one or more of the pollutants together in the amount and time that will harm the health of living things in the atmosphere (Incecik,1994). Under normal conditions; 78.09% nitrogen, 20.95% oxygen, 0.093% argon, 0.03% carbon dioxide (Güler and Akın, 2015). Air pollution can be defined as the levels of pollutants such as Sulfur dioxide (SO_2), particulate matter (PM), nitrogen dioxide (NO_2) and ozone (O_3) that have negative effects on the environment and health. This pollution disrupts the natural processes in the atmosphere and adversely affects public health.

A large proportion of passenger and freight transport in Turkey is done by motorized road transport. The most important factor that causes air pollution is the type, efficiency and amount of energy that causes pollution. Although motor vehicles on the road consume energy and generate various wastes, the transportation sector has an important share in the sector in terms of energy consumption rate as shown in Figure 1. Of the fuels used by road vehicles, gasoline and diesel fuels derive the most harmful substances (Öztürk, 1994). All of these will cause the environmental impacts of the vehicles to be seen to a great extent on the roads and the region.

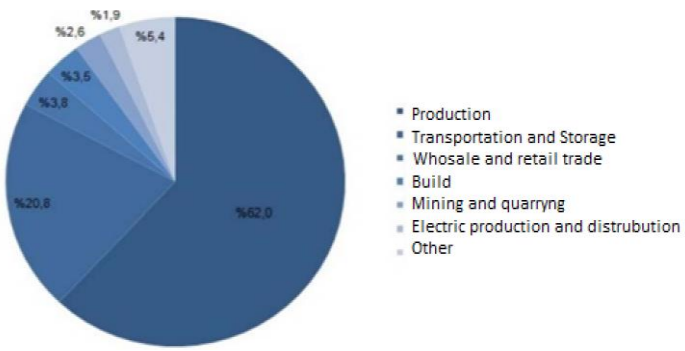

Figure 1. Distribution of final energy consumption by sector, 2017 (Öztürk, 1994).

The pollution caused by transportation is caused by greenhouse gas emissions. As shown in Figure 2, greenhouse gas emission values in our country have increased every year since 1990. Providing transportation in Turkey's overwhelmingly highways and principles of allowing the polluting road transport the main cause of environmental pollution due to transportation-related motor vehicle is road traffic.

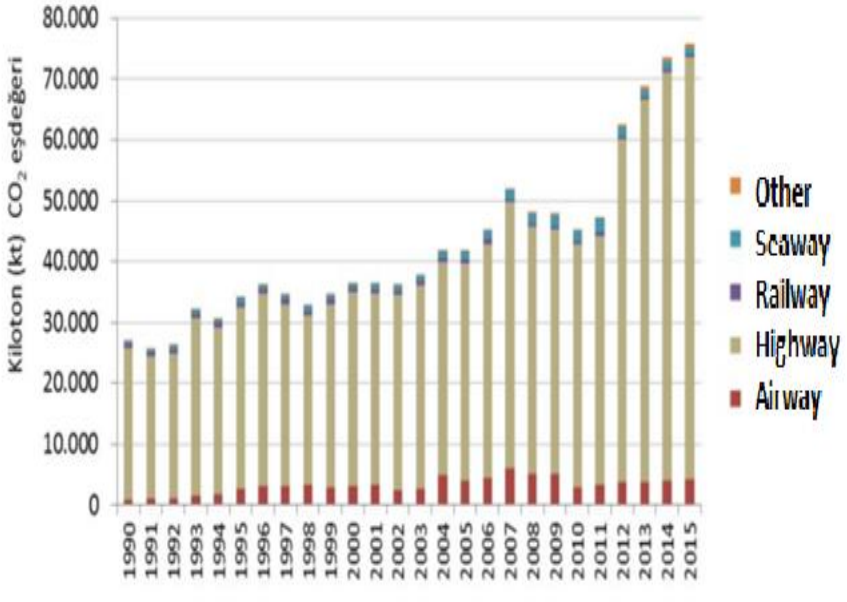

Figure 2. Greenhouse gas emissions by type of transport

3. Intelligent Transportation Systems

Transportation is a sector that is highly affected by technological developments. It is inevitable that transportation will renew, change and advance itself along with technological developments. Because transportation and life are in mutual interaction (Kumar et al., 2005). The benefits of technological advances should not be limited to the ease of construction of roads, stations and transport centers, but should be considered as a contribution to transport by many methods, such as sensors, microchips and various communication devices networks, which store data on the operation of complex transport networks (Kumar et al., 2005). In this axis, the presence of AUS, which includes high technology, traffic control and different transportation modes, aims to reduce the responsibility of people to think or make decisions by providing innovative services (Ezel, 2010).

Intelligent Transportation Systems (AUS) can be called as systems consisting of technologies such as electronic, data processing and wireless networks that provide security level and efficiency in the transportation network (UDHB, 2014). According to another view, AUS collects and processes traffic-related data and information and transfers them to the units and exchanges between the units using information and communication technologies (Shaheen and Finson, 2013).

With the increasing awareness of the AUS systems and the ease of providing solutions to the problems, a number of studies and applications have been made. For this reason, many institutions in many countries have attempted to establish AUS standards. The classification made by the ISO (international standards organization) shows that intelligent transportation systems are now divided into various service areas and service groups, as shown in Table 1.

Table 1. Service Areas and Classification of Intelligent Transportation System

Passenger Information
Traffic Management and Operations
In-Vehicle Systems
Public transport
Emergency
Personal safety related to road transport
Monitoring of weather and environmental conditions
Disaster response management and coordination
National Security

4. Region and Traffic Characteristics in the Study

Figure 3. Dilovası map-Google Earth Image

Dilovası is a settlement unit in Gebze which was separated from Gebze in 2008 and became a district. Dilovası, located in the industrialized East Marmara and Izmit Gulf, under the influence of the metropolitan area of Istanbul; It is a region where development is increasing with the power of industrialization. Rapid industrialization in this region has caused unplanned urbanization and infrastructure problems (Akbaş, 2013).

Dilovası district is located on D-100 highway and Istanbul Motorway (TEM) routes. These roads are intercity roads and are allowed to pass many classes of vehicles.

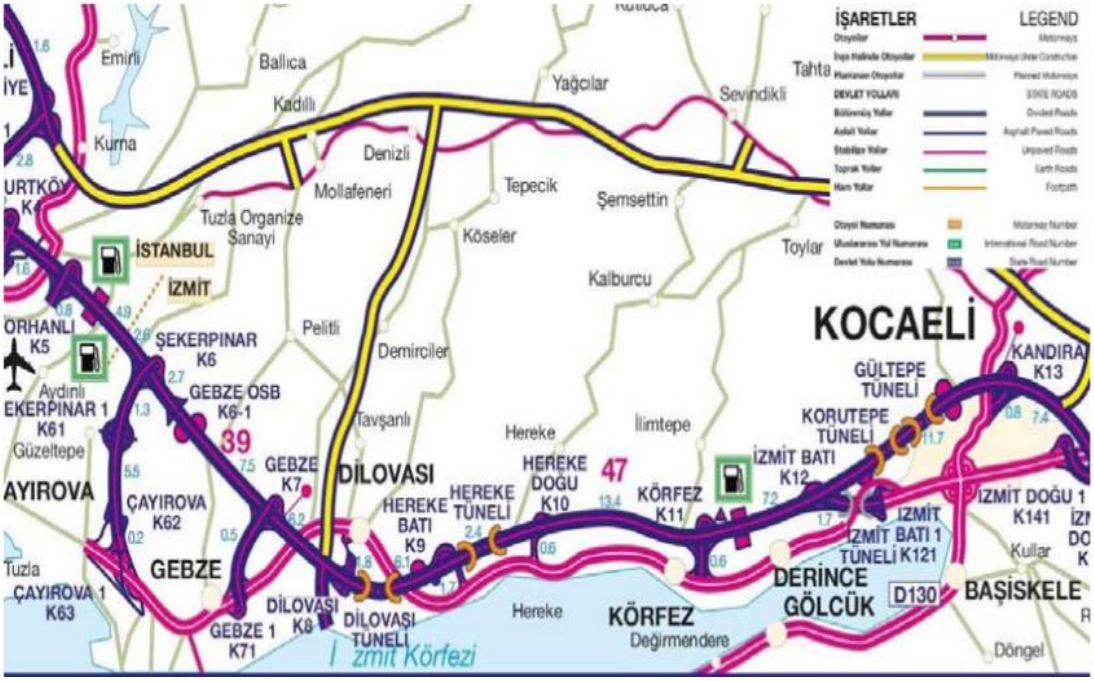

Figure 4. Dilovası region road view.

TEM (Trans European Motorway) is a route that starts from the borders of the Baltic Sea in Europe and passes through Central Europe to Edirne and reaches Istanbul and Ankara. In addition, in the east of our country, Tarsus reaches to the border gates of Habur and Cilvegözü in the Southeast and ends in Mersin. A certain section of the TEM Motorway passes through the Dilovası region and is one of the two main arteries in the Dilovası region (Figure 4). When the traffic volume on the TEM Highway is examined, according to the values obtained by the ratio of total traffic passing through a section of the road in both directions for a year in the Dilovası region, 28% of the traffic is composed of heavy vehicles and 72% is light vehicles (Table 2).

Table 2. Dilovası Region Highway Total Annual Average Daily Traffic (2017)

Section Name	Length-KM	Light Vehicle / Day	Heavy Vehicle / Day	Total Vehicle / Day
Gebze-Dilovası	6.2	58,232	22,143	80,375

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4.2. D100 Highway

D100 Highway is a State Road passing through Dilovası region. (Figure 4) The D100 highway is the name of the highway starting from the city center of Istanbul to a part of the Ankara road. Although it is a high standard road, it is not a highway. D100 When the traffic volume of the highway is analyzed, according to the values obtained by the ratio of total traffic passing through a section of the road in both directions for one year in the Dilovası region, 23% of the traffic is composed of heavy vehicles and 77% is light vehicles. (Table 4).

Table 4. Dilovasi Region D100 Highway Total Annual Average Daily Traffic (2017)

KKNO	Slice	Length-KM	Count Type	Light Vehicle / Day	Heavy Vehicle / Day	Total Vehicle / Day
100-7	3	15	OTSS1	24,511	7,278	31,789

The first priority environmental problem of Kocaeli province where Dilovası district is also connected is air pollution (Tekeli, 1994). Two of the air quality monitoring stations established by the Ministry of Environment and Urbanization in Kocaeli province are located in Dilovası district. The data of these stations show that Dilovası's air is quite dirty compared to other provinces.

Table 5. Dilovası Region Station Data (Hava İzleme, 2018).

Station	Parameter	Min.Date	Max Date	Min Value	Med. Value	Max value	Total	Std.Dev.	Data Rate
0141001 Kocaeli - Dilovası - İMES OSB 1- (Kocaeli-Dilovası)	NO2	9.4.2018	9.4.2019	-56.18414	23.6077157	200.3137	171	25.3397261	98.9071038
0141001 Kocaeli - Dilovası - İMES OSB 1- (Kocaeli-Dilovası)	PM10	9.4.2018	9.4.2019	0	30.1247918	1584.422	163	41.2325581	98.9071038
0141001 Kocaeli - Dilovası - İMES OSB 1- (Kocaeli-Dilovası)	CO	9.4.2018	9.4.2019	-274.6292	598.760625	11108.85	172	374.246776	98.9071038
0141000 Kocaeli - Dilovası İMES 2- (Kocaeli-Dilovası)	PM10	9.4.2018	9.4.2019	0.0006105	28.7261502	416.454	172	28.0261962	100.546448
0141000 Kocaeli - Dilovası İMES 2- (Kocaeli-Dilovası)	CO	9.4.2018	9.4.2019	0	388.915512	4262.762	182	216.163927	100.546448
0141000 Kocaeli - Dilovası İMES 2- (Kocaeli-Dilovası)	NO2	9.4.2018	9.4.2019	0.3160028	15.7917153	156.3448	182	14.6333202	100.546448

5. Investigation of the Proposed Method in Dilovası Region

The process of designing the transition is an effort to connect the two points in the most appropriate way. This is an economic comparison between eligibility options sought in the effort (Hava İzleme, 2019). As a result of the investigation on Dilovası maps, a route of 9,169 km is designed and horizontal and vertical axis information is given.

Figure 5. Designed Route

5.1. Route Properties

5.1.2. Project Speed

The road designed in the project will form part of the Istanbul - Ankara motorway. Vehicles will never leave the highway through the toll booths; they will not enter or exit. Therefore, the project speed of 120

km / h used on such roads and Istanbul-Ankara Highway was deemed suitable for the design in order to ensure the standards from the highway intact.

5.1.3. Geometric Standards

When selecting geometric standards, the intervals determined by the General Directorate of Highways and ensuring the comfort of motorways; The minimum conditions required for the continuity of the current comfort level of the Istanbul-Ankara motorway were tried to be met.

5.1.4. Horizontal axis, profile, superelevation

KGM determined the minimum curve radius R = 1000m according to the conditions. In the design of the road, an effort has been made not to go below this limit as a curve radius. Transition curves between the horizontal curves were not used. For maximum slope on the motorway, 4% value was considered appropriate at 120 km / h project speed. Considering the terrain conditions, Kocaeli-Istanbul direction of this slope route was applied as 6% for the first 3 km. Parabolic vertical curves were used between slopes in the profile. While placing the curves, it was considered that the conditions of visibility and adequate comfort could be established as criteria. In determining the geometric properties of curves, K = 100 value determined by General Directorate of Highways was provided. In order to provide drainage of surface water and to compensate for the effect of centrifugal force, circulation was applied. The minimum transverse slope is selected as roof in sections where the radius of curvature exceeds 5000 m and 2.5% is chosen as a roof.

5.1.5. Crossections

The cross-section used along the Istanbul-Ankara highway was taken and a cross-section with 2 x 3 lanes was envisaged. The cross-section is separated from the center by a 5 m refuge in two separate platforms and consists of 3 traffic lanes measuring 3.75 m with banquets of 1m inside and 3m wide on each platform. For filling cases, a width of 1 m is placed between the filling slope and the banquet. Guardrail shall be placed on this width. There is also a guardrail on both sides of the center median. Filling slopes take different slope slopes according to different heights

5.2. AUS Usage and Traffic Management

The first stage of event management design is the determination of air pollution. At this stage, T.C. The data provided by two Air Quality Measurement Stations installed by the Ministry of Environment and Urbanization will be evaluated. The system will evaluate according to the National Air Quality Index and will detect Air Pollution. The decision made by the system according to air pollution values can be in two ways: Blocking the current route and opening the current route to traffic. In line with these decisions, the road will be closed to traffic or opened. It is envisaged to apply a penalty system to the vehicles entering the route after the road is closed.

6. Evaluation

In this study, the reduction of the share of road traffic in the pollution by means of smart transportation systems applications within the TUBITAK COST Project was detailed and studies were carried out for Dilovası, which is the selected sample region in this regard. The situation of the Dilovası region and the usability of the intelligent transportation systems were examined. In the light of the data, the share of transportation on air pollution was found to be significant. Gases generated by road traffic, ie combustion of motor vehicles, constitute a large part of air pollution caused by transportation. In this study, it has been tried to reduce its share in air pollution and to dilute the air pollution in the determined region. The importance and future role of smart transportation systems has been recognized by the institutions which have a say on the highways of our country. All kinds of studies on smart transportation systems are remarkable. This project, which works together with AUS to reduce environmental pollution, is an example for both topics.

7. Results

Dilovası region is a residential area created by the industry, which was tried to be removed from Istanbul metropolis in the past. The main transportation arteries drawn by the industry and the settlement (Istanbul-Ankara Motorway and D100 Highway) increase the pollution in the region. Many studies and measures have been taken to prevent industrial air pollution in the region. This study is a special study carried out in the transportation area considering the presence of Istanbul-Ankara Motorway and D100 highway in the region. The new route is located in the north of Dilovası region, where the population affected by air pollution lives, and has been taken in a position to remove contamination contributions. The choice of this route was made compulsory in times of increasing air pollution and was released as an option at other times. The AUS drivers used at this point were provided with the same methods used in many AUS projects, and it was foreseen to place signs and illuminated signs on the roads. It has been found that air pollution from transport can be removed without compromising highway comfort and guiding drivers. The areas of use of intelligent transportation systems are generalized by ISO classifications. The examination of air and environmental conditions from these classes is considered as a classification covering air pollution. In addition, the assessment of the outputs of air pollution and the effect of traffic order according to these outputs made the system designed in the project under the heading of traffic management and operations.

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