

# WATER MANAGEMENT & WASTE WATER TREATMENT IN EGNATIA ODOS MOTORWAY

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The Egnatia motorway is one of the first large-scale public works to apply a system of environmental management, which organizes and implements environmental protection and mitigation measures in the design, construction, and operation stages of the project. The company's strategy is based on the Greek and European Community legislations on environmental protection, the international standards and the principles of sustainable development. The actions taken for environmental protection are the following: (a) protection and preservation of the cultural heritage (b) monitoring and assessment of the motorway impact on ecosystems and fauna (c) monitoring program of Road Traffic Noise (d) monitoring the concentration of pollutant gases (e) monitoring and management of the motorway's runoff waters (f) waste management (g) minimizing energy consumption.

Regarding monitoring and management of water pollution, Egnatia Odos S.A. works on preventing pollution incidents and protecting surface and ground waters from contamination. The run-off water from all kind of roads, especially motorways with high traffic volumes, is considered as source of pollution that contributes to the degradation of water quality. Specifically, runoff from motorways in rural areas can be responsible for severe environmental impact, especially long term, because they carry solids, heavy metals, chlorides, etc. Furthermore, this can lead to degradation of ecosystems and water pollution which has effects on humans, flora and fauna, which makes it imperative to take measures to address the problem.

For those reasons the company runs a complete and comprehensive project for the monitoring of the motorway's runoff water quality at the points of discharge to the adjacent receivers (i.e. rivers, lakes) during the operation and maintenance of the motorway. The selection of areas for carrying out the measurements is based on the Environmental Terms and the sensitivity of each eco-system. Additionally, treatment plants, called Pollution Control Units (PCUs) were constructed along the axis of Egnatia odos motorway. Those units treat in an efficient way the pollutants carried by runoff of surface water during rainfalls and additionally they collect and isolate waste leaks after accidents in the motorway. The operation and maintenance of the PCUs is of great importance, it is considered as an essential parameter for environmental protection along the motorway and deals with specific health and safety risks, such as confined spaces, toxicity, slips, trips and falls, manual handling, weather, transport of hazardous waste. Furthermore, contingency plans in case of accident and discharge of toxic loads in the motorway and certain specifications must be followed for the assessment and management of cumulative impacts on water bodies.

*Keywords: highway run-off; water pollution; water monitoring; waste water management; hazardous waste*

## 1. Introduction

Egnatia Odos S.A. is the company responsible for the design, construction, operation, maintenance and exploitation of Egnatia Motorway. The Egnatia Motorway, of approximately 1.000 km together with its vertical axes, constitutes one of the priority projects of the Trans-European Transport Network and is the communication link spanning Northern Greece from its western to its eastern border. Being a collector axis of the Pan-European Corridors leading from North to South, it is of great geostrategic importance for both the Balkans and South-Eastern Europe.

The Egnatia motorway is presented in Photograph 1 and has the following main characteristics:

- 50 road interchanges
- 350 entrance / exit over bridges and underpasses
- 1650 major bridges, with a total length of nearly 40 km, and many small ones
- 76 tunnels up to 4,8km long, with a total length of nearly 49,5km (or 99km measured as single-carriageway ones)
- 43 river crossings
- 11 railway crossings



**Photograph 1.** Egnatia Odos Motorway and its vertical axes

STRETCHING:	From Igoumenitsa to Kipi (Evros)
PROJECT SIZE:	1000 kilometres (vertical axes included)
SERVING THE REGIONS OF:	Thesprotia - Ioannina - Grevena - Kozani - Imathia - Thessaloniki - Kavala - Xanthi - Rodopi – Evros
LINKED WITH THE BORDERS OF:	Albania - FYROM - Bulgaria - Turkey, through nine major vertical axes
PASSING THROUGH THE TOWNS OF:	Igoumenitsa - Ioannina - Metsovo - Grevena - Kozani - Veria - Thessaloniki - Kavala - Xanthi - Komotini – Alexandroupoli
LINKED TO THE PORTS OF:	Igoumenitsa - Thessaloniki - Kavala - Alexandroupoli
AND THE AIRPORTS OF:	Ioannina - Kastoria - Kozani - Thessaloniki - Kavala – Alexandroupoli 332 towns and villages
PASSING NEAR:	30 regions of particular interest
SERVING THE INDUSTRIAL ZONES OF:	Ioannina - Florina - Edessa - Thessaloniki - Kilkis - Serres - Drama - Xanthi - Komotini – Alexandroupolis, either directly or through its vertical axes

PROPOSING AND FINANCING:	Archaeological excavations, protection of monuments, environmental protection works (biotopes, etc.)
TECHNICAL CHARACTERISTICS:	Dual carriageway of international standards with two traffic lanes per direction, a central reserve and an emergency lane.

The motorway impact zone corresponds to:

- 36% of the country's population
- 33% of the country's GNP
- 54% of the country's agricultural land and 65% of the total irrigated land, as far as the primary sector is concerned.
- 41% of the country's employment in industry-small trade, as far as the secondary sector is concerned. 51% of the country's extractive industry

The natural and manmade environment along the Egnatia project is exceptionally diverse, both through the mountains of Pindos and Western Macedonia, and the plains of Central / Eastern Macedonia and Thrace. The Egnatia Motorway runs through Greek mountainous and plain landscapes of exquisite beauty and ecological importance. Its alignment follows significant archaeological sites and natural resources of critical importance such as gold mines, deposits of various metals, wetlands, ground and surface waters, high capacity soils, etc. The Egnatia Motorway runs Pindos and other Greek mountains and reveals a variety of exceptionally interesting geological formations, valleys and ravines.

Along the route of the highway one can find:

- 17 Natural Habitat Areas protected under the European "Natura 2000" Network
- 4 Wetlands protected under the Ramsar Convention
- 70 wildlife conservation areas (formerly wildlife reserves)
- 270 sites and monuments of historical interest
- Most of the longest rivers in Greece (Evros, Nestos, Strymonas, Gallikos, Axios, Aliakmonas, Venetikos, Metsovitikos, Arachthos, etc).

The Egnatia motorway is one of the first large-scale public works to apply a system of environmental management, which organizes and implements environmental protection and mitigation measures in the design, construction, and operation stages of the project. The company introduces a new perception in environmental strategy by investing on environmental purposes a significant percentage of the total budget always in respect to the national resources, the international standards, and the principles of sustainable development. The company's complete and efficient environmental strategy, implements advanced technologies and is based on the Greek and European Community legislations on environmental protection.

Worldwide water is considered and treated as a renewable resource that is vital for life. Its existence, adequacy and the need for water protection is highly linked with the progress of the society. Nowadays, during a period with great ecological problems, the environment – and especially the water – is of growing concern of the international community while playing a key role in economic and political decisions of the society as well as in the development strategies among states sharing the water resources. Although there is plenty of water in nature, there are many problems related to the management and protection and for this reason, all stakeholders are invited to contribute to the protection and its optimum management according to the National and European legislation, and especially to the European Directive 2000/60 / EC.

The implementation of the Environmental Terms (Joint Ministerial Decisions for the approval of Environmental Terms) for the operation and maintenance of the Egnatia Motorway and its vertical axes, introduces the need for pollution control and protection of water bodies due to the operation and maintenance of the motorway. The Egnatia Odos SA is required to take the necessary steps to monitor pollution in the areas of surface water in its proximity, and also to take action plans and protection measures, according to the environmental legislation.

Additionally Egnatia Odos SA and specifically its Observatory, studies socio-economic, spatial, transport and environmental indicators and among others it studies two environmental indicators related to water. One of them records the number and density of intersections of the national road network with surface water before and after the operation of the Egnatia motorway, as an indication of

the potential effects on water resources through various emissions or pollutants discharged into surface waters and the other reflects the real impact of the operation of the motorway to the water quality. This indicator monitors, reviews and reflects pollution levels in adjacent to the motorway water bodies by identifying the areas in which pollution exceeds the statutory limits. Through this indicator integrated monitoring and management of pollution of waters due to the operation of the motorway is achieved.

## **2. Methods**

The run-off water from all kind of roads, especially motorways with high traffic volumes, is considered as source of pollution that contributes to the degradation of water quality. Specifically, runoff from motorways in rural areas can be responsible for severe environmental impact, especially long term, because they carry solids, heavy metals, chlorides, etc. Furthermore, this can lead to degradation of ecosystems and water pollution which has effects on humans, flora and fauna, which makes it imperative to take measures to address the problem.

Transport and infrastructure policies of the EU (TENs) meet economic, social and environmental objectives. So in areas where the network may be a risk of deterioration of water bodies from water runoff, strategies and actions for pollution monitoring, prevention and control are needed. In Decision No. 1692/96/EC of the European Parliament and of the Council of 23 July 1996 "on Community guidelines for the development of Trans-European transport network" and specifically, in Article 8 it is stated that "in the development and implementation of plans, Member States should take into account the protection of the environment by developing environmental impact assessments of projects of common interest which are to be implemented. According to the Law 3199/2003, harmonizing our national law on the protection and management of water resources with Directive 2000/60/EC, and in particular in Article 8, it is stated that all programs of measuring and monitoring water status, should among others include "response to pollution of aquatic ecosystems, regardless of the source of origin."

### **2.1 Water Monitoring**

For the protection of adjacent water bodies due to the operation of the motorway, the Environmental Dpt. of Operation, Maintenance and Exploitation Division of Egnatia Odos SA runs annual projects of sampling and analyzing water from water bodies in the vicinity of the Egnatia Motorway and its vertical axes. The selection of the areas and points for carrying out the samplings is based on the Environmental Terms and the sensitivity of each ecosystem

The samplings are carried out manually and/or with automatic samplers, by trained personnel in accordance with ISO 5667. Analyses are carried out in chemical laboratories accredited by the National Accreditation Council (ESYD) according to ISO 17025: 2005. The physicochemical parameters which are monitored, are the following: pH, turbidity, temperature, conductivity, Total hardness, BOD5, COD, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), dissolved oxygen (in situ), Total Dissolved Organic Carbon, fats and oils, nitrates, nitrites, phosphates, ammonium, lead, iron, cadmium, fluorine, chlorine, bromine, sodium, potassium, calcium and magnesium, as well as arsenic.



**Photograph 2.** Egnatia Odos Motorway and its vertical axes

In the following table the parameters analysed and the analysis methods are presented:

**Table 1.** Parameters and Analysis Methods

	Parameters	Unit	Analysis Method
Fats - Oils	Fats & Oils	mg/L	
Physicochemical analyses	Temperature	° C	
	pH	4-10	APHA-AWWA-WEF, 2005-4500H <sup>b</sup>
	Conductivity	µS/cm	APHA-AWWA-WEF, 2005-2510b
	Salinity	ppt	APHA-AWWA-WEF, 2005-2520b
	Turbidity	NTU	(2130, APHA AWWA WEF, 2005)
	Total hardness	French degrees	
Organic Load	BOD <sub>5</sub>	mg/l	APHA-AWWA-WEF, 2005-5210b
	COD	mg/l	APHA-AWWA-WEF, 2005-5220c
	TOC	mg/l	(5310B, APHA AWWA WEF, 2005).
	Dissolved Oxygen (DO)	mg/l	(APHA AWWA WEF, 2005).
Solids	TSS (Total Suspended Solids)	mg/l	APHA-AWWA-WEF, 2005-2540d
	TDS (Total Dissolved Solids)	mg/l	APHA-AWWA-WEF, 2005-2540c
Nutrient ions	NO <sub>3</sub> <sup>-</sup>	mg/l	APHA-AWWA-WEF, 2005-4500b
	NO <sub>2</sub> <sup>-</sup>	mg/l	
	PO <sub>4</sub> <sup>3-</sup>	mg/l	
	NH <sub>4</sub> <sup>+</sup>	mg/l	
	SO <sub>4</sub> <sup>3-</sup>	mg/l	
	F <sup>-</sup>	mg/l	
	Cl <sup>-</sup>	mg/l	
	Br <sup>-</sup>	mg/l	
	Na <sup>+</sup>	mg/l	
	K <sup>+</sup>	mg/l	
	Ca <sup>2+</sup>	mg/l	
Mg <sup>2+</sup>	mg/l		
Metals	Pb	mg/l, µg/l	APHA-AWWA-WEF, 2005- 3111b,d
	Cd	mg/l, µg/l	
	Fe	mg/l, µg/l	
	As	mg/l, µg/l	

Following the analyses of the samples, the correlation of concentrations of pollutants to other factors such as climatic data, technical characteristics of the road, traffic, rainfall, topography and geological data, is made. Furthermore, all data are registered in data bases for statistical and geo-spatial analysis.

Finally, the data are used for the forming of the Environmental Indicators which allow the integrated monitoring and mapping of the motorway impact on water quality and for undertaking prevention and/or protection plans if needed.

By this way the quality of water bodies in the proximity of the motorway is determined and additionally the ecological status of these regions, based on current standards for the pollution in motorways.



## **2.2 Pollution Control Units & Waste Water Treatment**

During the operation of the Egnatia motorway there is a potential for pollutants to be discharged from the road pavement to areas beyond the motorway boundary. There are two recognized sources of pollution. One source is pollutants collected on the road surface over time and washed off and transported during rainfall events. Another source is as a result of an accidental spillage of material on the motorway. Both sources of pollution can have a detrimental effect on the environment and in accordance with the Environmental Terms, mitigation measures must be implemented.

The “Guidelines for Conducting Road Works Designs (O.S.M.E.O)” of Egnatia Odos S.A. namely in Annex 3.1, provide that "the purpose of the hydraulic study is not simply the removal of water from the pavement, but also the direction of water to natural receivers in a way that minimizes the impact on the surrounding environment".

The construction of Pollution Control Units (PCUs) throughout the Egnatia motorway fulfilled the existing Environmental Terms, according to which, it is necessary to take measures to prevent pollution of water and other sensitive areas along the alignment of the motorway. Since 2006, almost one hundred (100) PCUs have been constructed throughout the motorway, especially in areas that are adjacent to rivers, streams and lakes considered as sensitive ecosystems.

The PCUs are hydrocarbon separator machineries, for waste containing undissolved and non-homogenized ingredients such as:

- petrol residues
- Internal combustion engine lubricant residues
- diesel
- fuel oil
- oils
- other form of light lubricants

Their use is mandatory by law since hydrocarbon residues are considered toxic and hazardous waste according to the European Directive and the greek JMD 13588/725/2006 Gazette B 383/03.28.06.

The runoff water is collected from the road pavement by the drainage system, which is constructed in a way that offers minimal loss of pollutants in transit to the pollution control facility, and it is directed to a Pollution Control Unit (PCU) which operates as follows:

- During every day operation it treats pollutants, which are washed from the motorway’s pavement
- In case of accidents and discharge of toxic loads on the pavement, it holds pollutants into the chamber of toxic waste, prior to safe disposal to a water body or other treatment facility.



**Photograph 3.** Pollution Contro Unit under construction

Egnatia Odos S.A. is responsible for the PCUs’ operation, control and maintenance and furthermore responsible for the hazardous waste management derived from the PCUs. This is of great importance, it is considered as an essential parameter for environmental protection along the motorway and should

deal with specific health and safety risks, such as confined spaces, toxicity, slips, trips and falls, manual handling, weather, transport of hazardous waste.

According to the existing legislation and the classification of waste into categories according to the European Waste List (Decision 2001/118/EC), liquid waste from the Pollution Control Units can be classified either under code 130508\* (waste mixtures of chambers debris and oil/water separators) or code 160708\* (waste containing oil), while the muddy residue can be classified under code 130502\* (sludges from oil/water).

The management stages of the hazardous waste collected from the PCUs of Egnatia motorway are the following:

- Collection of wastewater in tank trucks.
- Collection of mud residues in UN type barrels which are transferred by closed vehicles at the premises of the company responsible for their management.
- Transfer of liquid waste into storage tanks at the premises of the company responsible for their temporary storage.
- Uploading of liquid waste from the tanks and transfer by tankers or trucks at the premises of the company responsible for their management.



**Photograph 4.** Collection of waste from Pollution Control Units (Nestos river)

Before and during the collection of waste all the necessary safety measures are taken and emergency and decontamination materials are always on site.

The transportation of the hazardous waste is according to the existing traffic regulations and the ADR convention (i.e. speed restriction, transfer during non-rush hours, emergency response guide, ADR driving licences, vehicle signage, ADR security consultant, etc.). The transportation of waste from the tanks to the final recipient is made by tankers in accordance with the requirements of the IMDG Code and International maritime safety regulations

During the collection of waste all the appropriate documents are signed and sealed (i.e. the hazardous waste identification forms).

For the final disposal and management of sludge, bioremediation of contaminated soils and organic wastes is applied through disposal D8.

The final disposal and management of liquid waste includes the following actions :

- a) Separating water from oil by physical flotation
  - b) Aggregation - Flocculation
  - c) Dissolved air flotation
  - d) Biological treatment
- under the disposal and recovery codes: D9-D7-R3-R13

Regarding waste oil from separators (130508\* Code) the overall waste treatment is carried out in four stages (under recovery code R9):

- a) Receipt and storage
- b) Dehydration
- c) Rectifying
- d) Refining

Then the recovered materials are mixed with oils to produce final products.

### 3. Results

Analysis of the samples from the 150 predetermined points along the Egnatia motorway and its vertical axes, has revealed that almost all values of measured parameters are within limits according to the Greek legislation (Joint Ministerial Decision 5673/400, OG 192 / B / 14- 03-1997) relating to water intended for irrigation, and according to the law (JMD Y2 / 2600/2001, Government Gazette 892 / B / 11.7.2001) on water parameters features intended for human consumption. Besides, the results of the analyses do not show strong differences between the sampling periods and also between upstream and downstream samplings in the same water body.

In the following tables and figures the analyses results from the samples taken in Komsatos river are presented indicatively.

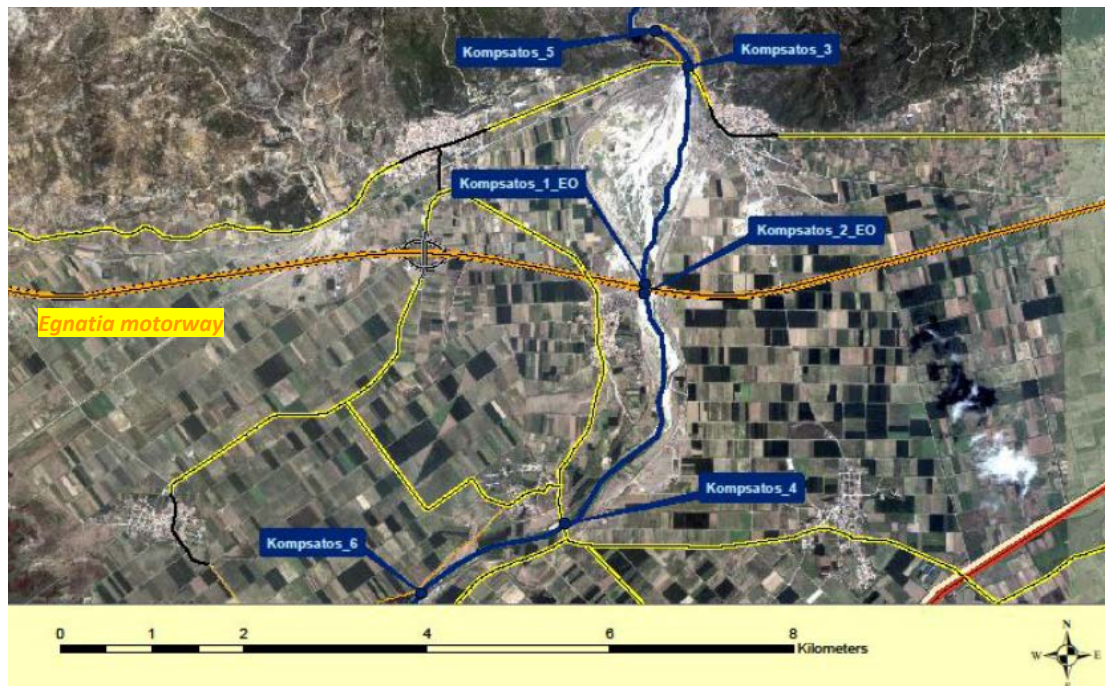
**Table 2.** Parameters Measured in Komsatos River (Region of Thrace)

Parameters measured	Unit	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Temperature	°C	10,3	10,3	11,2	10,9	11,4	11
pH		7,9	7,88	7,94	7,99	7,97	8
Salinity	psu	0,03	0,03	0,02	0,03	0,02	0,03
Conductivity	µS/cm	95	98	89	93	88	93
Turbidity	NTU	85	77	92	99	66	100
Water level	cm	20	20	25	20	25	25
Total hardness	F	16,83	17,36	15,77	16,48	15,59	16,66
Na <sup>+</sup>	mg/L	11,78	12,15	11,04	11,53	10,91	11,66
NH <sub>4</sub> <sup>+</sup>	mg/L	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
K <sup>+</sup>	mg/L	5,923	6,11	5,549	5,798	5,487	5,861
Ca <sup>2+</sup>	mg/L	47,85	49,36	44,83	46,84	44,32	47,35
Mg <sup>2+</sup>	mg/L	11,86	12,23	11,11	11,61	10,99	11,74
F <sup>-</sup>	mg/L	0,242	0,25	0,227	0,237	0,224	0,239
Cl <sup>-</sup>	mg/L	27,27	28,13	25,55	26,71	25,26	26,98
NO <sub>2</sub> <sup>-</sup>	mg/L	0,008	0,008	0,007	0,008	0,007	0,008
Br <sup>-</sup>	mg/L	0,042	0,043	0,039	0,041	0,039	0,042
NO <sub>3</sub> <sup>-</sup>	mg/L	8,338	8,601	7,811	8,162	7,724	8,25
PO <sub>4</sub> <sup>3-</sup>	mg/L	0,048	0,049	0,044	0,047	0,044	0,047
SO <sub>4</sub> <sup>3-</sup>	mg/L	56,04	57,81	52,5	54,86	51,91	55,45
Total Dissolved Solids (TDS)	mg/L	61	62	63	60	62	61
Total Suspended Solids (TSS)	mg/L	55,6	25,67	34,82	23,12	40,21	38,7

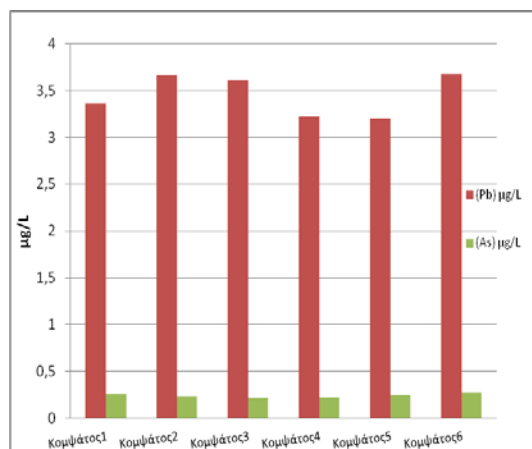


<b>Cd</b>	µg/L	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
<b>Pb</b>	µg/L	3,367	3,667	3,614	3,218	3,201	3,673
<b>As</b>	µg/L	0,251	0,225	0,215	0,223	0,249	0,276
<b>Fe</b>	µg/L	361,5	356,1	316,8	352,4	348,7	362,3

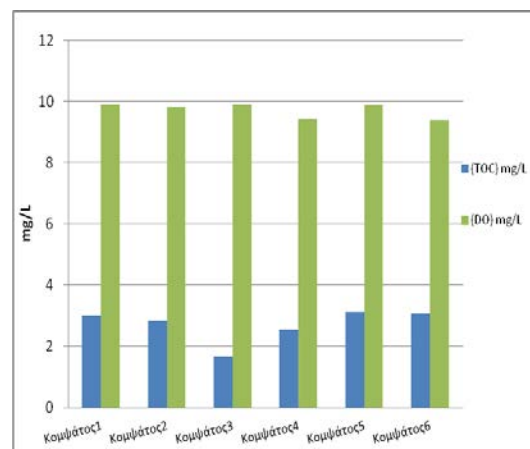
<b>TOC</b>	mg/L	3,003	2,845	1,684	2,547	3,123	3,076
<b>COD</b>	mg/L	7,507	7,112	4,210	6,367	7,807	7,690
<b>BOD5</b>	mg/L	3,003	2,845	1,684	2,547	3,123	3,076
<b>Total N</b>	mg/L	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
<b>Dissolved Oxygen (DO)</b>	mg/L	9,92	9,84	9,9	9,41	9,87	9,4
<b>Fats- Oils</b>	mg/L	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1



**Photograph 5.** Sample Points in Komsatos river basin



**Figure 1.** Concentrations of heavy metals at the sampling points of River Komsatos



**Figure 2.** Organic load at the sampling points of River Komsatos

Regarding, the hazardous waste management derived from the PCUs, the amounts collected approximately per year are 500 tonnes of liquid waste and 3 tonnes of sludge. More specific in 2013 the quantities of hazardous waste collected and managed according to the existing legislation are presented in Table 3.

**Table 3.** Quantities of hazardous waste collected and managed (2013)

Type of hazardous waste	Quantity (Kg)	Code no (European Waste list)
<i>SLUDGE</i>	<b>2.120</b>	<b>130502</b>
<i>WASTE CONTAINING OIL</i>	<b>515.600</b>	<b>160708</b>
<i>WASTE MIXTURES OF CHAMBERS DEBRIS &amp; OIL/WATER SEPERATORS</i>	<b>13.000</b>	<b>130508</b>

#### 4. Conclusions

Effects on water quality of water bodies from runoff water from motorways can be minimized by combining best management techniques, such as monitoring the water quality of both runoff and water bodies at the vicinity of the motorway and also by constructing and operating Pollution Control Units to lessen effects of motorway runoff on the water quality of receiving water.

Furthermore, contingency plans shall exist in case of accident and discharge of toxic loads in the motorway and certain specifications must be followed for the assessment and management of cumulative impacts on water bodies.

Regarding the monitoring program of Egnatia Odos S.A. and the measurements that have been carried out so far, it has been apparent, that the concentration of pollutants in the motorway's runoff and in the nearby water bodies don't exceed the legally specified limits and until now are not of significant importance.

As for the operation and maintenance of the PCUs is of highly importance, it is closely connected with water quality of adjacent receivers and it may present various types of hazards, requiring, at least, as a typical or particular workplace, performance of a risk assessment, definition of safe work practices, use of proper PPE and workers' training.

The Egnatia Odos S.A. will continue monitorong water quality and if it would be required protection measures will be taken. Furthermore, Egnatia Odos S.A. adopts the national and European policy regarding waste management and takes measures to prevent the generation of waste in order to reduce the quantity of such waste, whilst also protecting the environment and improving its environmental performance.

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