STUDY OF RETENTION/TREATMENT BASINS IN HIGHWAYS - CASE STUDY OF A24 (NORTHERN PORTUGAL)

Bentes, I.[a)], Monteiro, M.[b)], Duarte, A.[c)], Pinto, T.[a1)], Matos, A.[d)], Matos, C.[a2)]

a) Universidade de Trás-os-Montes e Alto Douro, Departamento de Engenharias, Vila Real, Portugal, ibentes@utad.pt; a1) tiago@utad.pt; a2) crismato@utad.pt

b) Instituto Portuário e dos Transportes Marítimos, Régua, Portugal, marisapdl@hotmail.com

c) Centro de Território, Ambiente e Construção (C-TAC), Universidade do Minho, Departamento de Engenharia Civil, Portugal, aduarte@civil.uminho.pt

d) Universidade de Aveiro, Departamento de Ambiente e Ordenamento, amatos@dao.ua.pt

Abstract

In runoff water from highways are diluted several pollutants, that can affect groundwater resources, that depend on the traffic, as well as, on the automobile wear, type of road, infrastructure installed and waterproofing area. These discharges have impacts on the environment. To mitigate such impacts usually there are used retention/treatment basins.

In this paper there was analyzed runoff water quality and the efficiency of five basins located in a highway in northern Portugal, in a sensitive area, where are explored mineral waters. It was verified that the results are according with Portuguese legislation in terms of limits of discharge. The treatment efficiency of theses basins is good.

The obtained results from the previous analyses were compared with others case studies with different traffic volume and different precipitation patterns.

Keywords: Retention/treatment basins, highways, water quality.

1 Introduction

In recent decades, the need for better mobility of properties and individuals involved the intensive construction of road infrastructure, particularly highways (Brites, A., 2005). This infrastructure resulted in an increase of impermeable areas reducing of infiltration, increasing the flows linked to drainage systems, increasing the probability of local over-flows, changing the water level, decreasing the concentration time at the basins and decreasing the air and water runoff quality from the platform by the existence of road traffic (Bichança, MF, 2006).

Highways in exploration cause negative effects on soils and water resources. Pollutants produced mainly by the car traffic, lay down on the pavement being transported by surface runoff from these facilities. In many cases it is necessary to create a system that addresses these waters, usually through a retention basin / treatment before being discharged into the water corps.

The road traffic contributes to the production of the following pollutants: heavy metals, hydrocarbons, particulate matter and organic matter. The accumulation of pollutants is primarily a function of paved area, the intensity of traffic, maintenance activities and repair of road infrastructure, as well as the meteorological characteristics, the adjacent land use and the existence of accidents involving the transportation of toxic or dangerous substances.

The pollutants that are present in the runoff of road infrastructure are also part of the combustion process of diesel, petrol and gas and of some parts of vehicles degradation. In with respect to emissions of hydrocarbons, these are generated in the lubricating oils and fuels. The incomplete combustion of compounds go in the environment as carbon monoxide (CO), nitrogen dioxide (NO2), ketones, aldehydes and polycyclic aromatic hydrocarbons (PAHs). Consumption of oil in the crankcase contributes to the emission of aromatic hydrocarbons (fluoranthene, pyrene, and naphthalene fenanthrene).
Unlike organic compounds, metallic compounds are not degraded in the environment and bioaccumulate. Heavy metals and organic micropollutants may show up as dissolved or particulate bound. (Ramísio et al., 2006)
Characterization studies of highway runoff have shown that Zn, Cd, Ni and Cu are predominantly in the dissolved form, Fe and Al are mainly particulate bound, while Pb and Cr are distributed between the two forms (Hvitved-Jacobsen et al, 2005; Sansalone, J., et al, 1996).

Another aspect to consider is that during the winter season due to the danger of ice and snow, roads are treated with salt and rock salt, which introduces the atmosphere huge amounts of sodium chloride and magnesium as well as traces of cobalt and chromium.
Table 1 shows the main types of pollutants originating from road and its source.

Table 1 - Types of pollutants originating from road and its source (Leitão *et al*., 2006)

Pollutant	Source
Heavy metals (Pb, Zn, Fe, Cu, Ni, Cd, Mg, Cr)	Tyres and brake pads, fuel, engine oil additives, rust and security guards.
Cadmium	Tyres and brake pads.
Cromium	Tires, brake pads and bearings.
Cupper	Radiators, tires and brake pads.
Lead	Fuel, Tires and brake pads.
Zinc	Security guards, lubricants, tires and brake pads.
Hydrocarbons (PAH, Petróleo, combustíveis)	Oils, fuels and emissions.
PAHs	Fuel, plastics and pavement.
Nutrients (N, P)	Fertilizers, fuels and motor oils and gaseous emissions.
Organic matter	Vegetation, animal droppings
De-icing salts, herbicides	Chemicals road maintenance

An important aspect to take into account when characterizing the water quality of runoff is the intensity of rainfall that dilutes the pollutants (Leitão et al, 2006).
In Table 2 are the typical concentrations of some pollutants in runoff from roads.

Table 2 - Typical concentrations of some pollutants, adapted from (Leitão et al., 2006)

Pollutant	Typical Concentration
SST (mg/l)	30 - 60
COD (mg/l)	25 - 60
BOD5 (mg/l)	-
N-total (mg/l)	1 - 2
P-total (mg/l)	0,2 - 0,5
Pb (μ g/l)	50 - 125
Zn (μ g/l)	125 - 400
Cu (μ g/l)	-
Cd (μ g/l)	5 - 25

It is known that the quality of water runoff from these highways is conditioned by the structure and the environment. The type of road, traffic intensity, type and age of vehicles and velocity beyond the intensity of rainfall that has already been mentioned, are factors which affect the concentration of pollutants.

With regard to the types of roads, what matters is to know the velocity limit. On a highway in Portugal, the limit is 120 km / h, while a main route (IP) is 80 to 100 km / h. As for traffic, the type and age of vehicles define the emission of pollutants. New cars pollute less than older ones, since their design requires the preservation of the environment (James, 1999). The vehicle speed has a direct influence on the emission of pollutants by tire wear. According to James (James, 1999), there is an optimum speed, between 50-60 km / h, where, at this speed, the engine works more efficiently, generating less pollution.

In Table 3 is the possible content of heavy metals released due to wear of the tires on two different types of roads.

Table 3 - Release of heavy metals due to tire wear (Leitão et al., 2006)

Road Type	**Pb**	**Cu**	**Cr**	**Ni**	**Zn**	**Full wear**
			g/km/ano			kg/km/ano
HighWay	1145	329	241	230	810	657
IP	506	115	84	80	284	347

According to James (James, 1999), the volume of traffic directly influence the accumulation of heavy metals in soil and vegetation. Roads where the volume of traffic do not exceed 15,000 vehicles per day, generate low levels of pollution and do not become problematic. For an average daily traffic (ADT) between 15,000 and 30,000 vehicles there should be some concern. For a traffic exceeding 30,000 vehicles, there may be serious impacts on the environment.

Table 4 presents illustrative values of water quality of discharge, obtained in various studies on roads with distinct average values of daily traffic.

Table 4 - Values illustrative of the water quality of discharge, obtained in various studies (Leitão et al., 2006)

Country	**TMD**	**SST(mg/l)**	**Pb (mg/l)**	**Zn (mg/l)**	**Cu (mg/l)**	**Cd (mg/l)**	**Cr (mg/l)**
Norway	8000	162-2420	62-690	91-740	10-430	-	-
Germany	47000	181	245	620	117	-	-
UK	720	-	28,1	16,6	6,5	-	-
Germany	500	-	122	165,6	75,9	-	-
Reading, UK	98200	160-704	43-1800	140-4200	50-1000	<1-13	<20

As shown in Table 4, there is no linear relationship between TMD and the production of pollutants. It should also be considered pavement quality. Pavements are generally asphalt or concrete, there are two types of asphalt, smooth and porous. The smooth asphalt surface is hard, while the porous is more brittle, since its surface is composed of coarser grain sizes. In relation to the properties of these two types of asphalt, it is important to note that the porous asphalt has greater capacity to retain water and polluting matter, thus reducing their transport to the environment (Leitão, 2006).

2 Some cases of study in Portugal

In order to compare the runoff quality from A 24 highway, drag E1, presented in this study with other case studies it is described the case of basins of Fatima, associated with Highway No. 1 (A1), the basin of pretreatment with infiltration of Highway No. 6 (A6) (Estremoz / Borba) and the pond of the A23 highway - connection Covilhã (North) (Leitão et al. 2006, Albuquerque, M., et al., 2006).

Case 1: A1-Fatima

Basins of Fatima was the first runoff treatment system from road infrastructure to be implemented in Portugal, having been built in 1990 to protect the massive Jurassic limestone's, which have high vulnerability to pollution (Oliveira et al. , 2001) and which were being altered by runoff from the A1 platform.
This basin receives water from 22 800 m^2 of the A1 motorway, has a volume of 9148 m^3, a retention time of 3 hours and TMD was 30 299 vehicles per day, at the time of the study.
To evaluate the performance of basins of Fatima it took place a monitoring campaign that lasted from March to May 2002, which consisted on the collection and analysis of 31 samples whose results are presented in Table 5.

Case 2: A6 – Borba

The study area on highway No. 6 (A6) is located on the aquifer system Estremoz-Cano, which depends on the public water supply for about 37 000 inhabitants (Water Institute, 1999).
The Borba basin is a pretreatment basin receiving a drainage area of 5580 m2, has a volume of 265 m3 and the TMD associated with this section is 2918 vehicles per day.
The monitoring campaign took place from January to May 2004 and analyzed 37 samples during this period. The results are presented in Table 5.

Case 3: A23 - Link Covilhã (North)

A23 highway, is comprised of two sections with 2.0 km and 4.2 km. This area is classified in part as National Agricultural Reserve (RAN) and National Ecological Reserve (REN).
Tailing ponds are designed to preserve existing water quality for irrigation and public supply. They have two compartments, one for settling and another for the separation of oils and fats (grease trap). The TMD in this section is about 10 500 vehicles. This basin was monitored, with two sampling campaigns, one in January and another in May 2006.
Table 5 presents the ranges of values obtained in the three case studies as well as the limits established by the Portuguese legislation.

Table 5 - Range of values of A1, A6 and A23 (Leitão *et al*., 2006, Albuquerque, M., *et al*., 2006).

Parameter	Range of values A1	Range of values A6	Range of values A23	VLE (DL236/98 -Anexo XVIII)	VMR (DL236/ 98- Anexo XVI)	VMA (DL236/ 98- Anexo XVI)
pH	6,3 – 7,4	6,6 - 7,7	7,1 – 7,2		6,5-8,4	4,5-9,0
SST (mg/l)	10,0 – 872	0,3 - 86,0	10,0 – 65,0	60	60	-
Zn (µg/l)	62 – 736	21- 6410	<100	-	2000	10000
Cu (µg/l)	27 – 76	< 5 – 21	15 – 16	-	200	5000
Pb (µg/l)	2 – 58	< 5 - 9	-	-	5000	20000
Cd (µg/l)	< 0,5	< 0,5	-	-	10	50
Fe (µg/l)	86 – 3030	50 – 990	-	-	5000	-
HAP (µg/l)	< 0,05 – 0,08	< 0,05	0,42 – 0,93	-	100	-
Oils and fats (mg/l)	3,2 - 40	< 3 – 36,5	0,42 – 0,93	15	-	-

3 Case Study

This study will present the results of water quality of five detention/treatment ponds, called BT04, BT05, BT06, BT07 and BT08 and located on the A24 (Figure 1), a motorway located in northern Portugal (Fig. 2) and crossing a sensitive area of exploitation of mineral water. Dicionário

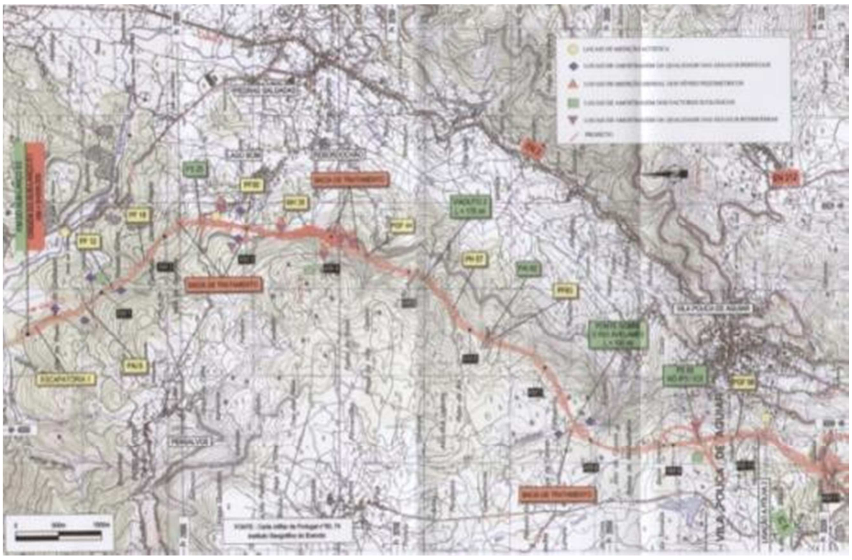


Figure 1 - Location of haul E1-retention basins and treatment (Operscut, 2009)

Figure 2 - Location of study area, the National, District and Municipal (Veraki, 2009)

The design of the five basins was made for a retention period of three hours and an average intensity of precipitation of 10 mm / h (equivalent to a uniform rainstorm 6 h duration, which is twice the retention time, with 2 years return period).
All basins have the sedimentation basin, the hydrocarbon separation tank and a deplete system. Basins are open, with permanent water level.
Table 6 shows some characteristics of retention basins, which were built in impermeable material covered with soil.

Table 6 - Retention basins and their storage volumes.

Basin	Paved area (m^2)	Slope area (m^2)	% paved area	Volume (m^3)
BT04	19868	7928	71,5	825
BT05	24199	7011	77,5	903
BT06	11900	15706	43,1	768
BT07	16151	3401	82,6	590
BT08	14230	385	97,4	436

The study allowed us to compare the results obtained in the physical / chemical properties of water runoff with the limit discharge values established by the Portuguese legislation as well as comparing them with case studies of the A1, A6 and A23 with different traffic volumes and intensity of precipitation. Also allowed to analyze the efficiency of the five detention/treatment ponds, built on the A24, for some of the parameters analyzed.

3.1 Methodology

The methodology used in this study was as follows:

1º Analyze the monitoring reports to identify the physical / chemical parameters that were analyzed in the five detention/ treatment ponds

Analyze the monitoring reports to identify the physical / chemical parameters that were analyzed in the five detention/ treatment ponds on the following dates (Table 7):

Table 7 - Date of sampling campaigns.

1ª Campaign	30 and 31 of May 2007
2ª Campaign	04 and 05 of September of 2007
3ª Campaign	27 and 28 of November of 2007
4ª Campaign	06, 07 and 08 of May of 2008
5ª Campaign	12, 13, 14 and 15 of October of 2008
6ª Campaign	10, 11 and 12 of December of 2008

The parameters analyzed were the following:
• Total Suspended Solids (TSS);
• chemical oxygen demand (COD);
• in Biochemical Oxygen Demand (BOD5);
• aromatic hydrocarbons (PAH);
• Oils and Fats (GL);
• Heavy Metals: Cadmium (Cd), copper (Cu), Lead (Pb), Chromium (Cr) and Zinc (Zn).

2º Compilation of a new sampling in BT08

With the aim of assessing the possible evolution of the parameters under study from 2008 to 2010, was drafted an additional sample in BT08. BT08 was chosen since this basin is the basin which is associated with a higher percentage of paved area. The concentration values obtained were analyzed and discussed the same way as the concentrations contained in the monitoring reports.
The collection of samples from additional campaign in BT08, held on 18 and 19 March 2010 in the entry and in the exit of the basin, respectively, and the parameters analyzed were the same of the monitoring reports.

3º Presentation, analysis and discussion of results

Based on the analytical results given in the reports and in the additional campaign held in BT08, it was analyzed the concentration of each pollutant in the output of the detention/ treatment basin and compared with the limits imposed by legislation. A summary was made on the concentration of metals and was determined the efficiency of some basins.

4º Comparative analysis of the results obtained with the other road infrastructure (with different traffic volumes and intensities of precipitation)

Finally it was completed a comparative analysis of the values obtained in the five basins of A24, with the typical values mentioned in literature (James, C., 1999) and with values reported in the literature for the other case studies in Portugal (Leitão et al., 2006, Albuquerque, M., et al., 2006).

4 Presentation, Discussion and Analysis of Results

4.1 Analysis of Monitoring Reports

The environmental monitoring of runoff quality from a road infrastructure has as ultimate goal, if necessary, the definition of mitigation measures to safeguard, among others, the surface water and groundwater. For this it is necessary to evaluate the environmental loads in question and the efficiency of built treatment systems.

In this case, the subsection E1 of the A24 motorway, it is also to safeguard the groundwater recharge related to hydro concessions from Pedras Salgadas among others. Environmental problems associated with road runoff platform are related to the main pollutants and their concentrations as well as the factors influencing its concentration. Measures to mitigate these problems contemplated the construction of detention/ treatment basin for the removal of pollutants associated with road runoff platforms.

It was analyzed the effluent pollutant concentrations from basins, comparing them to the limits required by DL236/98, Annexes XVI and XVIII, Table 8.

In order to assess the evolution of pollutant concentrations in a study from 2008 to 2010, it was proceeded to a new campaign to collect samples (BT08-1). This campaign was carried out in BT08, once this is the basin which has associated a higher percentage of paved area.

The analysis of Table 8 shows that the concentrations of all elements in the output of the basins, under study, are lower than the limits established by law. It is observed that the BT08 generally have higher concentrations of oils and fats. This may be due to the higher percentage of paved area associated with it.

The concentration of Cd on the exit is low, much lower than the recommended maximum value for the quality of water for irrigation (VMR), which is 0.01 mg / l.

As the VMR for copper is 1 mg / l, lower than the VLE, we chose to compare the concentrations with VMR, since doing this, we fulfill the VLE.

Lead concentrations shown to be greatly reduced, partly because of the mandatory use of unleaded gasoline.

4.2 Parameters evolution in BT08

Regarding the evolution of parameters concentrations in BT08 from 2008 to 2010, it appears that the concentrations of all elements in analysis are below the limit values established by law.

There is an increased concentration of PAHs.

In relation to the total fractions of copper, cadmium and lead, there was a significant increase, especially lead.

Similarly, there was also an increase in dissolved and total chromium in samples collected in this last campaign.

Regarding the concentration of dissolved and total zinc, the values are below the maximum values of the range of values of the other campaigns.

Summarizing, although the increase in concentrations of some heavy metals at the entrance of the basin, the concentrations are still within the limits imposed by legislation.

Table 8 - Range of values obtained in the five basins of the A24, E1haul.

		BT04		BT05		BT06		BT07		BT08		BT08-1		DL236/98	
Parameters	Units	Entry	Exit	Entry	Exit	Entry	Exit	Entry	Exit	Entry	Exit	Entry	Exit	VMR	VMA
pH		7-8,4	4,9-7,9	5,3-8,8	5,4-7,4	7,9	6,7-8,2	6,6-8,5	6,6-8,5	5,8-6,9	6,5-7,8				
SST Totais	(mg/l)	<2 - 17	<2-9,1	<2-16	<2-35	11	2,5-162	14-18	<2-14	3,1-290	<2-41	29	<20	60	-
COD	(mg O2/l)	<20-50	<20-46	<20-54	<20-29	45	<20-76	<20-148	<20-52	<20-400	<20-104	80	<20	150	-
BOD5	(mg O2/l)	<2	<2-12	<2	<2	4,2	<2-12	<2-8,3	<2-12	2,9-14	<2-12	10	<10	40	-
Oils & Fats	(mg/l)	<0,2	<0,2-0,35	<0,2-0,49	<0,2-0,57	1,2	<0,2-2,7	<0,2-0,66		0,5-9,9	<0,2-0,73				
HAP	(µg/l)	<0,27	<0,27	<0,27	<0,27	< 0,19	<0,27	<0,27	<0,27	<0,19	<0,27	<0,5	<0,5	100	-
Cd dissolved	(mg/l)	<0,0005	<0,0005	<0,0005	<0,0005	< 0,0002	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	0	0	0,01	0,05
Cd Total	(mg/l)	<0,0005	<0,0005	<0,0005	<0,0005	< 0,0002	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,1	<0,1	0,2	-
Cu dissolved	(mg/l)	<0,001-0,0016	0,00082-0,0045	<0,0005-0,0019	0,0011-0,0019	0,0098	0,0018-0,0098	0,016-0,011	0,0014-0,0036	0,0046-0,018	0,0013-0,0037	0	0	0,2	5
Cu Total	(mg/l)	<0,001-0,0018	<0,001-0,005	0,00063-0,0031	0,0016-0,0054	0,012	0,0018-0,0069	0,0031-0,013	0,0014-0,0069	0,0057-0,052	0,0019-0,0081	<0,3	<0,3	1	-
Pb dissolved	(mg/l)	<0,001	<0,001	<0,001	<0,001	< 0,0002	<0,001	<0,001	<0,001	<0,001	<0,001	0	0	5	20
Pb Total	(mg/l)	<0,001	<0,001-0,0014	<0,001	<0,001	0,0012	<0,001	<0,001	<0,001-0,0028	0,00058-0,015	<0,001-0,0014	<1	<1	1	-
Cr dissolved	(mg/l)	<0,005	<0,003	<0,003	<0,003-0,0093	0,0025	<0,003-0,0044	<0,003	<0,003	<0,003	<0,003	<0,1	<0,1	0,1	20
Cr Total	(mg/l)	<0,003	<0,003	<0,003	<0,003-0,0035	0,024	<0,003	<0,003	<0,003	0,0026-0,0089	<0,003	<0,1	<0,1	2	-
Zn dissolved	(mg/l)	0,0017-0,0042	0,0017-0,043	<0,001-0,03	0,0048-0,039	0,03	0,016-0,077	0,011-0,032	0,0087-0,036	0,0033-0,34	0,013-0,056	0,31	0	2	10
Zn Total	(mg/l)	0,0047-0,016	0,008-0,043	0,0033-0,03	0,012-0,039	0,062	0,016-0,12	0,039-0,051	0,016-0,037	0,064-0,62	0,022-0,075	0,51	<0,1	0,5	-

4.3 Summary of metals concentrations

Chart 1 shows the average percentages of heavy metals off the detention/ treatment basin.
It was found that Zn is the heavy metal with the highest concentration found in the river discharge treatment, with about 75% when compared with other heavy metals. Next is chromium with 12%, although, in relation to its limit value, had low concentrations compared to other heavy metals. Copper contributes 7% of the concentration of all metals. Finally, with 2% and 4% have cadmium and lead, respectively.

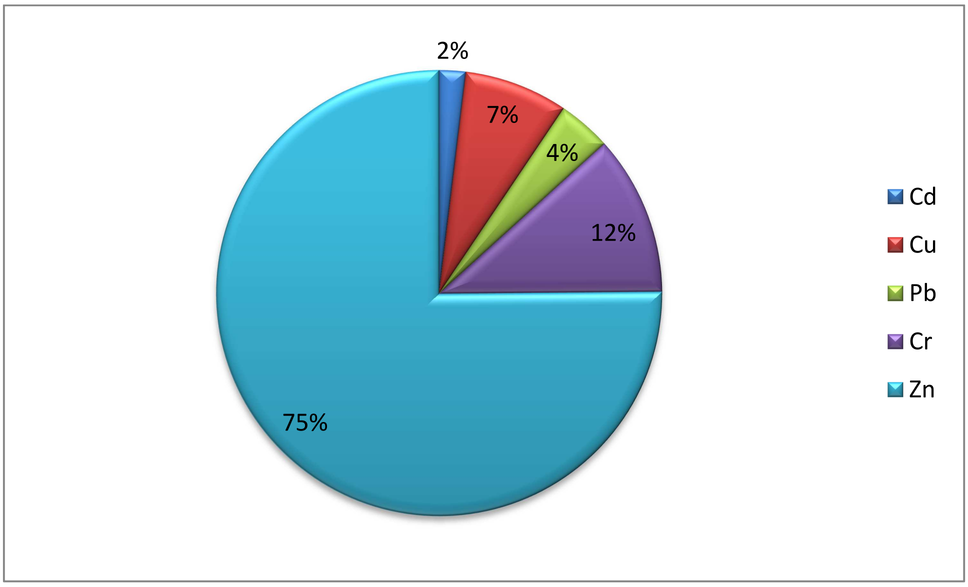


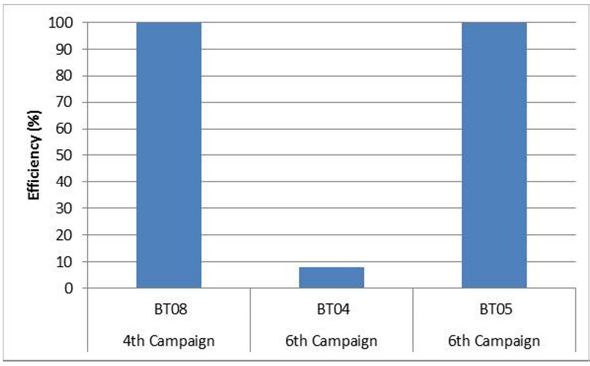
Chart 1 - Average of heavy metals from all basins.

4.4 Efficiency of Retention/Treatment Basins of A24

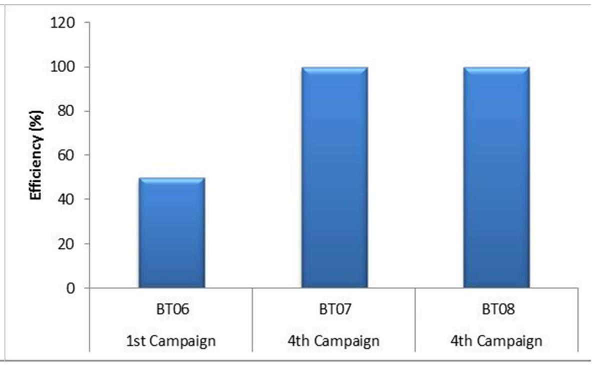
Given the trace concentrations of many of the parameters under study or the lack of values entering or leaving the detention/treatment basin only in some situations it was possible to calculate the efficiency of the detention/treatment basin of A24. These situations are represented in Chart 3a) to e). In the event that the output value is vestigial the efficiency of the basin was considered 100%.

For COD in BT08, chart 2a), 4th campaign, there was 100% efficiency while at the 6th campaign the basins and BT04 and BT05 had efficiencies of 10 and 100% respectively.

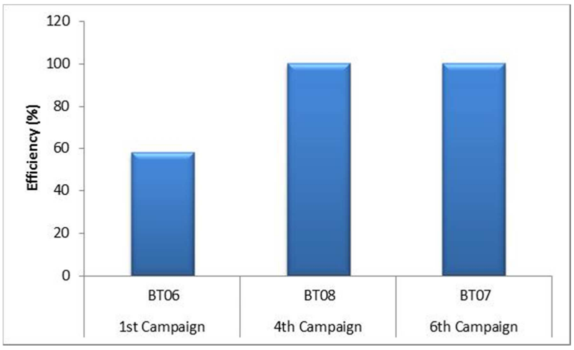
For BOD5 in BT06, the first campaign removed 50% of concentration. BT07 and BT08, on the 4th campaign, had 100% efficiency.



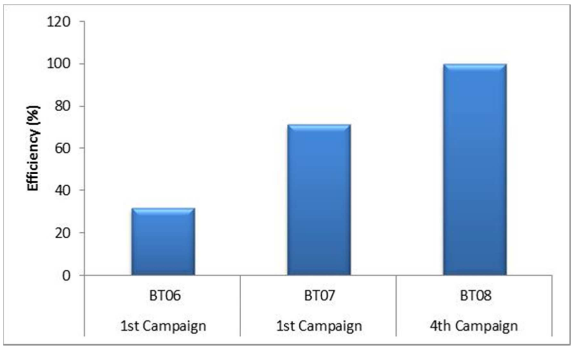
a) COD



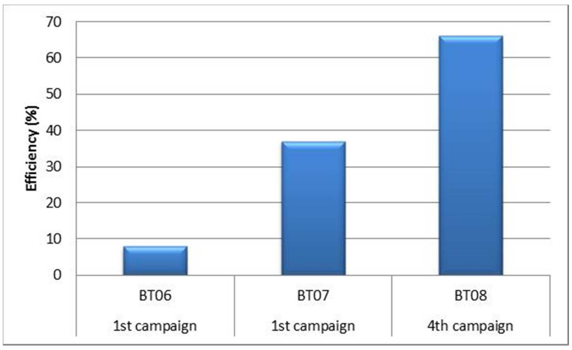
b) BOD5



c) OILS AND FATS



d) LEAD



e) COPPER

Chart 2 - Efficiency of the basins of the A24

In the 1st campaign made on BT06 the reduction efficiency was 58% in oils and fats, while in BT08 and BT07, at the 4th campaign, had efficiencies of 100%.
Regarding the lead removal efficiency it was 32% in BT06 and 71% in BT07 on the 1st campaign while the BT08 had 100% efficiency on the 4th campaign.
The copper removal efficiencies on BT06, BT07 and BT08's was 8% to 37% in 1st campaign and 66% in 4th campaign, respectively.

4.5 Comparison with other Portuguese case studies

Table 9 shows the values obtained in the A24, the reference values of the INAG and the values proposed on the case studies of A1, A6 and A23.

Table 9 - Range of values obtained from the A24, Bibliography and A1, A6 and A23.

Parameter	**A24**	**(James,C., 1999)**	**A1** (Leitão *et al*.,2006)	**A6** (Leitão *et al*.,2006)	**A23** (Albuquerque, M., *et al*., 2006)
pH	4,9-8,5	-	6,3 – 7,4	6,6 - 7,7	7,1 – 7,2
SST (mg/l)	<2-162	30-60	10,0 – 872	0,3 - 86,0	10,0 – 65,0
Zn (µg/l)	<100	125-400	62 – 736	21- 6410	<100
Cu (µg/l)	<300	-	27 – 76	< 5 – 21	15 – 16
Pb (µg/l)	<1000	50-125	2 – 58	< 5 - 9	-
Cd (µg/l)	<100	5-25	< 0,5	< 0,5	-
HAP (µg/l)	<0,5	-	< 0,05 –0,08	< 0,05	0,42 – 0,93
Oils and fats (mg/l)	<0,2-2,7	-	3,2 - 40	< 3 - 36,5	0,42 – 0,93

Comparing the values referenced by INAG with the values obtained in the various case studies it appears that the recommended values for TSS and Zn are generally exceeded in the case studies, contrary to what happens for Pb and for Cd.

It can be seen that parameters are higher in A1, in particular the concentration of total suspended solids, copper, lead and iron. This phenomenon may be related to the high existing traffic on this highway.

On the A23 there was a higher concentration of PAHs.

Zinc concentration is higher for the A6 and this could be related to the type of security guards installed in the infrastructure and its age.

It is noteworthy the fact that higher concentrations of pollutants are associated with higher traffic values. However, the conditions under which samples are collected, including precipitation phenomena and state of preservation and operation of the drainage system, may influence the concentrations.

5 Conclusions

This study quantified the concentration of pollutants from E1 of A24, surging to five detention/treatment ponds located within the infrastructure, during episodes of precipitation. These runoff remains on basins for a minimum of three hours. After the runoff retention basins, concentrations of pollutants in the samples were compared with the emission limit values (ELVs) with the maximum allowable (VMA) and the maximum recommended (VMR), required by law. It was found that after the retention time in the detention/treatment basin, output values comply with legislation.

It was found that the efficiency of treatment basins is generally high.

A24 is a highway operating for only five years, and has an average daily traffic (ADT) of approximately 5000 vehicles. These values are quite small when compared, for example, to the Highway No. 1 (A1) that has an ADT of 30,299 vehicles or with Highway No. 23 (A23), which has an ADT of 10,500. The TMD value of A24 is higher than the A6 TMD (TMD 2919). It is thought, therefore, the concentrations of pollutants from the platform of the A24, the A23 and A6, are lower than concentrations of A1. The fact that the concentrations of pollutants entering the river on the A24 are low, is consistent with that in literature (James, 1999). According with this James, (1999) a road with a TMD lower than 15 000 vehicles a day, do not involve severe impacts on the environment. However, it should take into account the process of accumulation of pollutants, including heavy metals and fractions that do not dissolve, that may cause damage in the future, considering its accumulation.

The TMD may be a key factor, but the existence of rainfall preceding the sampling, the conservation status of the drainage system and treatment, as well as the state of adjacent land use, may influence the concentrations of parameters to evaluate.

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