Environmental Aspects of Water in European Road Pavements and Embankments

This report is the result of a questionnaire in the project "COST 351 - Water Movement in Road Pavements and Embankments", with the acronym WATMOVE. WATMOVE is a European project with the main goal to increase the knowledge required to improve highway performance and to minimise the leaching of contaminants from roads and traffic.

The questionnaire was divided into two parts, one concerning "Pavement drainage" and the other concerning "Environmental aspects of water in road pavements and embankments". These are the answers regarding the environmental aspects.

Any country was invited to answer the questionnaire, and the WATMOVE members are grateful that as many as 18 countries answered – 16 European and two states in the USA. The countries answering were: Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Norway, Poland, Portugal, Romania, Serbia & Montenegro, Slovenia, Sweden, United Kingdom and the states of California and Virginia in the USA.

Some countries returned more than one questionnaire. Where this report directly adresses state of practise in countries, these answers are combined and taken as one. Where the country is not mentioned, each answer/questionnare is considered equally representative.

Most answers to the questionnaire concern state level administration, but also local level is represented.

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Environmental aspects of water in road pavements and embankments

Roads - and the traffic they carry - influence the surrounding environment by sources of pollution. The contaminants due to traffic can be released by vehicle exhaust emissions, vehicle component wear, road degradation and littering and spills. But also road maintenance and the road materials themselves can cause contamination.

Water is the most important media transporting the contaminants from the road surface to the environment and adjacant water bodies. The crossfall of the road ensures that the water from rainfalls runs to the drainage system at the side of the road (runoff water). But in especially older cracked roads, water will also seep through the pavement surface, and move down through the pavement materials (seepage water). The environmental aspects of runoff water and seepage water are dealt with separately in this report.

Figure 1 below shows the principles of simple drainage systems in smaller roads in rural areas.

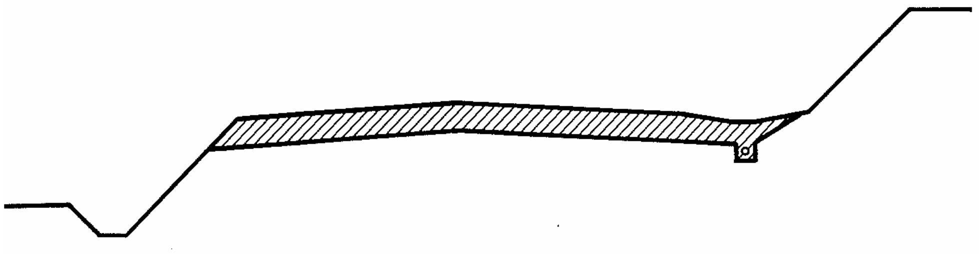

Figure 1: Cross profile of a smaller road having a ditch in the left side and a conventional drain in the right side (from Thagesen, Lærebog i vejbygning, Polyteknisk Forlag, 1984)

Regulations on water quality for roads

When asked about relevant regulations or water quality standards, 7 of the 18 answering countries, answer that their country has regulations that apply specifically for roads. The remaining countries use other relevant legislation which is interpreted and applied to roads.

The legislation covering roads is typically legislation regarding environmental protection, groundwater or river water. These regulations generally cover both runoff and seepage water.

For most of the countries the regulations refer to maximum concentration of the pollutant (11 countries), while 4 countries refer to maximum load of pollutant. One country (Virginia, USA) sets regulations to stormwater runoff, in total annual load of pollutant. Examples of maximum concentration requirements to drinking water can be found in the reference: http://www.finlex.fi/fi/laki/kaannokset/2000/en20000461.pdf

Approximately half the countries distinguish between point sources and diffuse sources of pollution. The countries that do distinguish, explain what difference this makes to sampling and regulation:

- Point sources will have “end pipe solutions” (Sweden)
- No sampling required for diffuse sources (Poland and Virginia)
- Diffuse pollution is attributed to highways i.e. discharges that cannot easily have a discharge permit applied to it. Point source pollution is associated with steady state discharges from industry, i.e. sewage treatment works, factories etc. (UK)
- To regulation – catch and cleaning system (Croatia)
- The measurements take place at sites, where road traffic is the only source. In urban areas, where point and nonpoint sources mix up, the road runoff is collected and purified in the public sewer system (Germany)
- In most cases, the stormwater runoff is considered as non-point source. For California DOT it has been classified as point-source (California)

The risk of pollution from roads

Runoff water and accidents and spillages are considered equally serious in causing environmental pollution from the roads, as seen from Figure 2 below. Whereas water seeping through the pavement is not generally seen as a serious threat.

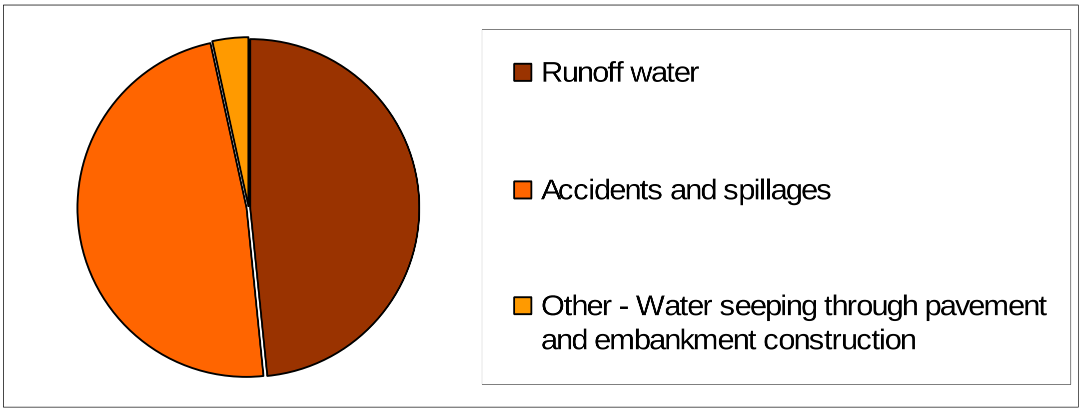

Figure 2: Which do you consider to be the most serious cause of environmental pollution?

The pavement experts answering the questionnaires most often have experienced pollution due to runoff water:

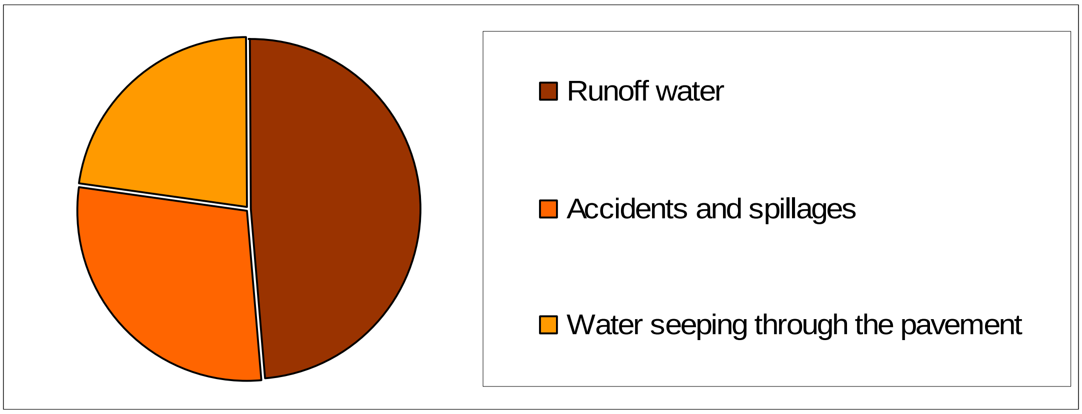

Figure 3: Do you have experience with environmental pollution from different sources?

There are several methodologies on how to survey and monitor pollution on roads.
A little more than half the countries (8 of 14) differentiate between the approach adopted for "normal" events and for "incidents". The countries that do differentiate, explain the difference this makes:

- Pollution from roads is divided into "permanent" pollution and incident pollution. The permanent pollution is the consequence of traffic, and incident pollution is the consequence of accidents. Permanent pollution is treated according to the environmental vulnerability and presence of water protection zones with various devices. Incident pollutions are prevented by retention ponds (Slovenia)
- Normal events include stormwater runoff. Traditional stormwater "Best Management Practices" are employed to capture and treat runoff. Incidents include traffic accidents where the response is a function of the hazardous material (Virginia)
- Groundwater reservoirs that constitute sources of water may be protected against discharges in conjunction with accidents (Sweden)
- Routine runoff has different constituents to accidental spillages. The risks are assessed using different assessment tools (UK)
- Immediate removal of hazardous materials versus normal maintenance (Greece)
- Traffic accidents involving spillage of toxic substances are considered when the road is expected to serve such sort of traffic in a relevant way (Portugal)
- Traditional stormwater "Best Management Practices" are employed to capture and treat runoff. For incidents, special measures are taken dependant on the hazardous material (Germany)
- Runoff generated from ilicit and traffic accidents activities are monitored independently (California)

The typical pollutants, for which tests are carried out in the different countries are:

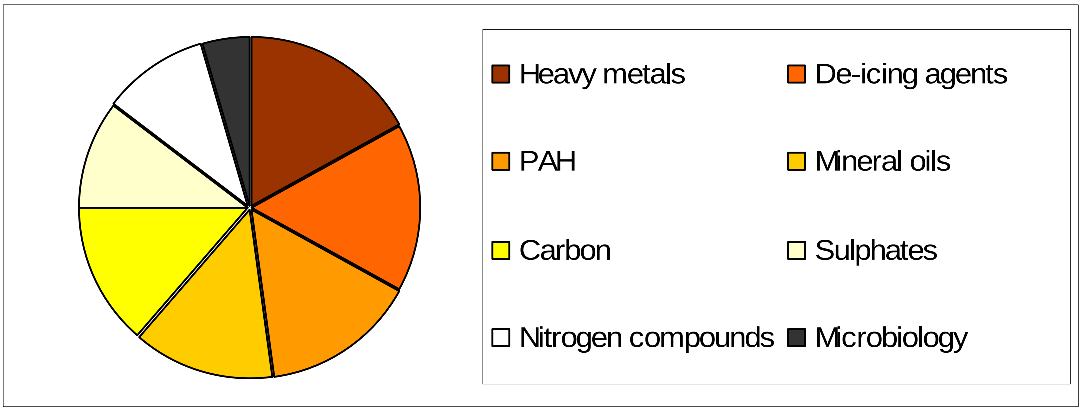

Figure 4: For which types of pollutants do you carry out tests?

Runoff water

Runoff water runs from the road surface, via drainage systems, to the following water bodies:

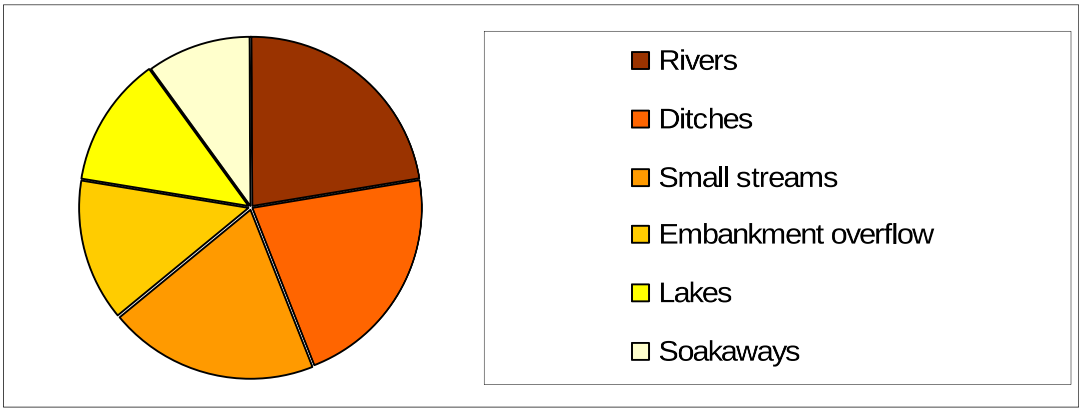

Figure 5: Where is the runoff directed?

There are different requirements to the quality of the runoff water and to the construction of the elements that the water is passing. The following deals with retention ponds, soakaways and final discharge to existing watercourses.

Retention ponds

Sometimes a retention pond is used between the drainage system and the natural water body. The purpose of the retention pond is both for water quality purposes (19 answers) and for control of peak flows (16 answers). One answer mentions that the retention pond is also meant for retention of accidental spillages.

The questionnaire asked whether retention ponds were always, sometimes or never used. When it is only sometimes a retention pond is used, its necessity is governed by:

- Depending on regulation
- Depending on environment sensitivity
- Only in plain areas of the country
- Based on locality (available space)
- Along high volume roads
- Usually in connection with construction of new roads
- When need for purifying water, storage or if no natural recipient.
- Restricted outlet watercourse and upstream of an infiltration basin
- When the risk of pollution, flood risk or accidental spillage has been identified.
- New projects that exceed 1 acre of new pavement, and also require a quantity or nuisance flooding control.
- Retention ponds are considered best practice, but is not always possible due to the right of way and land availability
- When the Environmental Impact Study identifies a significant impact for local water resources
- When the design of road banks and ditches and their infiltration capacity shows, that according to the calculated probability of heavy rainstorms, the receiving water body is disturbed too much.

The water goes through the following treatment before it runs to its final destination:

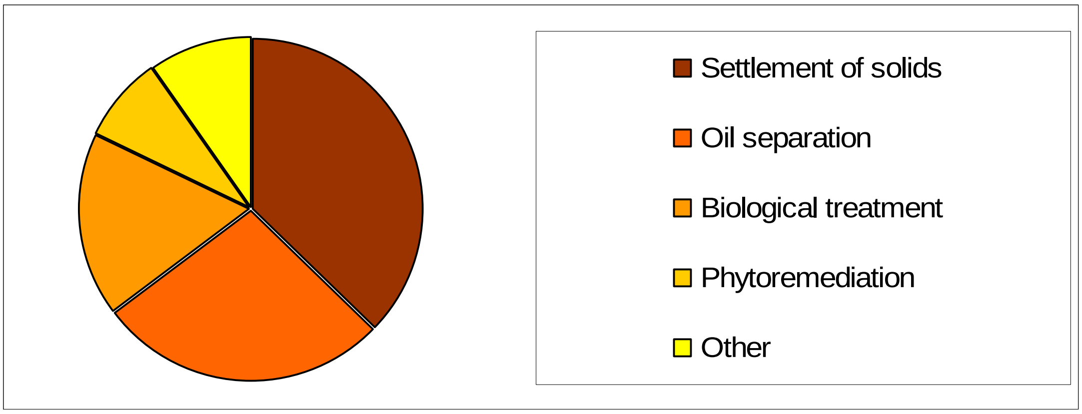

Figure 6: What treatment is applied to the water before it goes to its final destination?

The answer "other" covers soil infiltration, chemical addition (coagulation) and filtration.

The levels of permitted pollution of the water coming from the retention pond, or the construction details, are usually dependent on parameters as traffic level or locality. An overview of these dependencies is given in the table below.

Factors, that the levels of permitted pollution or construction details are dependent on		
Factor	**No. of countries answering "YES" for dependency**	**Dependency**
Traffic level	10	- For ADT > 2000, construction details are dependent on land use, geological, soil and groundwater conditions, and quality and runoff regime of the receiving water bodies (Germany) - The permit for larger construction sites is more restricted than for smaller construction sites (California) - Dimensions of pond depend on traffic (France) - ADT > 5000 is the limit. In coming legislation, limit will be defined according to the natural conditions and passenger equivalent (Slovenia) - Only retention ponds on motorways and main roads (Serbia & Montenegro and Denmark) - Dependent on traffic volume and function/type(UK) - Traffic density and vulnerability of recipient decides if retention pond will be constructed (Norway)
Locality	13	- Roads in protection areas around drinking water wells are required to be made of material with very low pollutant leaching (Iceland) - For ADT > 2000, construction details are dependent on land use, geological, soil and groundwater condi-

		tions, and quality and runoff regime of the receiving water bodies (Germany) - Pollution is controlled only in sensitive areas in regard to water quality (Serbia & Montenegro) - The type of Pollution Control Unit is chosen based on locality (Greece) - Restrictions depends on recipient (Denmark) - Dependent on environmental/ecological sensitivity and on the presence of groundwater protection zones (Slovenia, Croatia, Norway and Portugal)

Soakaways

A soakaway can for instance be used in local hollows where water cannot be lead to other recipients than the groundwater. Water infiltrates either directly to the groundwater or through some terrain surface. Figure 7 shows an example of soakaways.

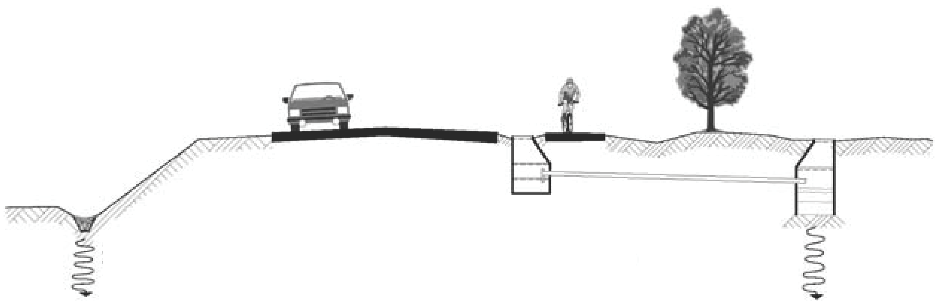

Figure 7: Example of soakaways (from Danish standard).

None of the countries answer that they use soakaways where the water is filtered directly into the groundwater. All water goes first to the vadose zone (terrain surface).

Approximately half the countries using soakaways have requirements to the water that flows from pavements into soakaways. The requirements are based on the following regulations:

- The water must as a minimum go through sedimentation and oil separation before it goes to the soakaway (Croatia)
- It is not permitted to infiltrate polluted water directly into groundwater (Slovenia)
- Soakaways are rarely ever used; infiltration through intact surface soil is much more effective (Germany).
- Drinking water (Norway)
- Law of environmental protection (Denmark)
- Groundwater Regulations set standards for discharges of different substances (List I and List II) (UK)
- Environmental regulation – on the conditions that must be fulfilled for wastes introduced into waters and ground, and on the substances especially harmful for the water environment (Poland)

Construction requirements to soakaways are dependent on following factors		
Factor	**No. of countries having requirement**	**Dependency**
Groundwater's vulnerability to pollution	11	- Requirement: More than 3 days vertical infiltration/percolation-time. Specification: "Surface water and groundwater protection" according to groundwater's value and vulnerability (Sweden) - If the insulation of the main basins of underground (potable) waters is poor, the drainage must be tight and water runoff purified before going to the environment (ground) (Poland) - The design of a soakaway must give due consideration to pollution control and stormwater control which will be determined by the existing ground conditions for any given site i.e. lithology, porosity, depth of unsaturated zone etc. (UK) - Minimisation of leaching harmful substances into groundwater (Iceland) - Enhanced protection measures are taken during construction, in order to protect groundwater. E.g. location of construction facility sites or machines parking are prohibited in those areas (Portugal)
Existing quality of the groundwater	8	- When the groundwater is of high quality (and has no natural insulation), the drainage must be tight and water runoff purified before going to soakaways (Poland) - High treatment efficiency prior to final disposal (Croatia) - Risk of pollution is partly dependent upon the quality of groundwater although all groundwater is treated as a valuable resource under the Groundwater regulations (UK).
Use of the groundwater	12	- Human consumption and irrigation uses are protected (Portugal) - No soakaways in areas of drinking water (Denmark) - No discharge in protected zones (Croatia) - Discharge of runoff within protected zones requires additional safety precautions. In highest protected areas (Zone 1), discharge may not be allowed (UK) - All the main basins of underground waters are designated to be used (Poland)

Runoff water flowing to existing watercourses

Figure 5 showed that runoff water most often goes to existing watercourses such as rivers, streams and lakes. The levels of permitted pollution in the water flowing to the watercourses depend on certain factors as shown in the table below.

Factors that the levels of permitted pollution are dependent on		
Factor	**No. of countries answering "YES" for dependency**	**Dependency / Requirement**
Surface water quality	9	- Treated runoff must be near recipient's quality (Croatia) - The quality must not be worse than without discharge (Germany). - The water body should not be affected by the discharged water. A total maximum daily load is established and regulated - calculated based on flow in existing watercourse (California) - Plan to construct Pollution Control Units in all areas considered environmentally sensitive (Greece) - Total Maximum Daily Load implementation plan (Virginia)
Use of the surface water	10	- If water is used for drinking water, no discharge of runoff water is allowed (Slovenia) - If there are specific uses to be protected, there are restrictions in order to protect the surface water (Portugal and California) - The situation has to be kept at a level that allows further use of the water. Measures adopted in construction and management of the road are used to prevent problems (Germany) - Total Maximum Daily Load is a function of the use of the surface water (Virginia)
Discharge in the recipient	4	- Usually discharge should not be larger than 0,1 of mean low flow (Q) (Slovenia) - The flow regime in the recipient must not be changed too much by the discharge (Germany) - Water bodies are listed (303d water body list) as impaired water bodies based on specific pollutants (California)
Flow in the existing watercourse	6	- The flow regime in the recipient must not be changed too much by the discharge (Germany) - Requirements to final concentration in watercourse (Denmark)

Performance of runoff water systems

It is always important to ensure that the constructed elements perform as intended – and that they keep up the performance with time. The questionnaire reveals that half the countries check that the system is performing to the regulations or design requirements on a routine basis.

Examples of intervals and responsible agencies:

Interval	**Responsible agency**	**Country**
Frequency settled by the road AIA (e.g. once a year)	Responsible for the road	Portugal
Performance must be reported on an annual basis or as requested by the regulators	Reported to the California Water Resource Control Board	California
Occasionally	Environmental and civil engineering inspection	Slovenia
Once per year minimum – and after runoff events that cause the principal spillway to be exceeded	Virgina DOT, Asset Management	Virginia
During and after construction	Local environment agencies	Romania
Before project implementation	The investor	Poland
Every 6 months	Managing Agent / Environment Agency	UK

Sampling of runoff water

Far the most countries have taken samples of runoff water, some on a regular basis and some for research projects. Table 1 reports on procedures and frequency of sampling.

The countries report that the pollutants that give the most problems in runoff water can be prioritised as:

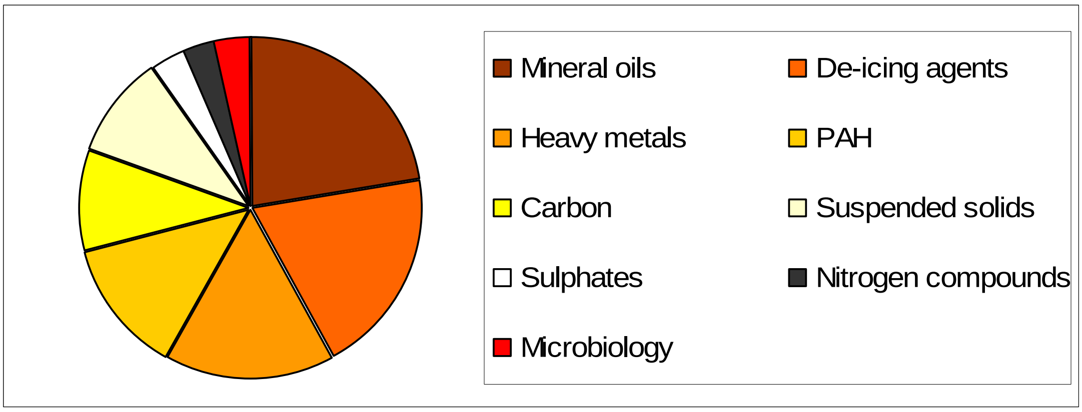

Figure 8: With which pollutants do you have the most problems in runoff water?

Table 1: Procedures for sampling of runoff water

Country	**Where do you sample**	**How**	**When**	**Laboratory sample preparation procedures**
California	Edge of pavement, right of way, end of discharge pipe	Single grab, composite grab, automatic composite. Using equipment Sigma 950. Sample storage is mostly at 4 °C with appropriate acid preservation. The holding time is based on the pollutant and it may vary from 48 hours to 6 months.	Wet and dry seasons. Mostly during the wet seasons – October – end of April. Frequency depends on the storm event. Up to 100 subsamples based on the rain intensity and flow rate. Up to 8 storm events per year.	Mostly USEPA and Standard methods.
Croatia	"Checking manhole"	Special hydrotechnical laboratory samples	Twice a year – at least	ISO
Czech Republic	Along highways in the small settlers and retention ponds	Point sampling and passive sampling. Equipment: glass beaker, graduated cylinder, sampling bottle or semi-permeable membrane devices. Samples are stored in dark glass bottles in refrigerator (3-4 °C) for max. 24 hours. The water is analysed before filtering.	Twice a year - spring and autumn - (semi-permeable membrane devices). When point sampling about three times a year, at various time during the year.	
Denmark	Retention ponds	No standards. Equipment i.e. plastic container.	Only research	ISO
Finland	One site is monitored regularly. Samples from collector well and also from small private pond and outlet ditch of the pond.		Once a year (autumn)	C1 SFS 3006. If we use by-product then also: ICP-MS As, Cr, Mo, Se; pH SFS3021; EC SFS-EN 27888, COD SFS 3036; SO4 Turbid.method.
France	Collectors All motorways and Ring Road	Equipment: Automatic sampler, flow controlled. Storage depends on the parameter. A temperature of 4 °C is mentioned.	Samples are taken all the year, both continuous and monthly sampling are mentioned.	AFNOR and ISO

Germany	At some highly traffic loaded motorways, as an environmental showcase with the aim of testing and updating regulations.	Runoff water is collected directly at the road edge as a composite sample over two weeks. Bulk deposition is collected in several distances from the road edge once a month. Water is filtered, and both filtered water and sediment are analysed. Pollutant load and concentration are calculated. No standard method for sampling is used. Analytical standard methods are used. Equipment: Glass- and PE-tubes and bottles, PVC-sampler connected to road edge by frost resistant mortar. pH and electric conductivity are measured directly in the field. Samples are stored in a cool place (5-8 °C), filtered as fast as possible, then dried (sediment) and/or preserved with nictric acid (water), and analysed within 14 days.	Sample is collected every two/four weeks all year round.	Filtration: DIN 38409-02 (Modified because sediment will be digested and analysed afterwards). Sediment and bulk deposition material: HF/HNO3-microwave digestion, aqua regia digestion (DIN ISO 11466 1997-06) will be tested also.
Greece	Plan to sample at the entrance to Pollution Control Unit that we have just constructed		Plan to sample relative to rain event and incident	
Norway	Approx. 5 sites		12 times a year – all year	CEN / ISO
Poland	At all outlets where wastes are lead to the environment		Relative to rain event (Most of the time, the outlets are dry) Old roads: once a year New roads: twice a year	ISO
Portugal	At the entrance of treatment systems or at dis-	Portuguese standards. Equipment: Automatic water sampler model ISCO 6700.	No established frequency. Usually samples are taken	Mostly based on the “Standard Methods for the

	charge ditches	Usually no preservative actions in the field. Samples remain in the field for 2 hours to 2 days, in average.	from September to May – most wet months.	Examination of Water and Wastewater".
Romania	From side ditches.	Standard procedures. The water is analysed after filtering.	Relative to rain events and/or incidents. Or when necessary, after visual inspection of the road pavement condition	Romanian standards – now transition to European standards.
Serbia & Montenegro	In drainage system and channels along the road.	Equipment: Standard equipment for water sampling according to ISO 5667 standard. Water is analysed after filtering. Samples are preserved according to ISO 5667 standard.	Related to specific projects.	ISO
Slovenia	At outflow points from retention basins and sometimes as research on the ditches and directly from the road surface.	No standards for sampling. Water is poured into plastic or glass bottles. Water is analysed after filtering. For heavy metals, acid is added to the water (pH<2), samples are taken to the lab as soon as possible.	Samples are taken two or four times per year. In the forthcoming legislation this approach will change. Sampling will be per volume discharged. For research purpose, samples are taken relative to rain event.	Depending on the parameters analysed. Sometimes dependent on the lab.
Sweden	No standards.	No standards are followed. Water is analysed before filtering.		SS_EN ISO/IEC 17025
UK	At the point of discharge prior to treatment, and after treatment systems prior to discharge into the receiving water.	Samples are collected and stored in bottles. Storage in a refrigerator. Water is analysed before filtering. Reference: "Long Term Monitoring of Pollution from Highway Runoff: Final Report", Highways Agency and Environment Agency, WRc Ref:UC 6037, 2002	Relative to time of year and rain event – usually 10 wet weather events at a site.	Check reference.
Virginia	No sampling required.			

The pollutants that are being tested for are shown in Figure 3. Other parameters looked for are: COD, Cl-, SO4-, HcT, NOx, TOX, temperature, pH, toxicity tests, aggregates, nutrients, biologicals, organics and electric conductivity.

Seepage water through the pavement and embankment

Water – and the pollutants it might include - can run through cracks in the road surface, or from unpaved areas as the shoulders and the central reserve, down through the pavement. Some of it will be caught by the sub-surface drainage systems, some may infiltrate with the groundwater.

In construction of the roads, this movement of polluted water is sometimes attempted limited through different construction details as:

- Impermeable layers, geotextiles or lining technology (Croatia)
- Geo barrier or liner and sub-surface drainage systems (UK)
- Asphalt concrete is considered impermeable. When motorways pass areas of drinking water production, the total road area is surfaced (including central reserve). Kerbs lead runoff water to sub-surface drains (Denmark)
- Dense coating / pavement (Finland)
- In areas for drinking water use, dependent on the geological and soil conditions, only limited or no embankment overflow is allowed. The runoff is purified and/or discharged outside of the protected area. If necessary a sealing made of clay or plastic materials below the embankment is applied (Germany)
- Application of foil between subgrade and subbase if the groundwater is used for drinking water production (Serbia & Montenegro)
- Protection against infiltration of storm water by provision of sealing, watertight kerbstones for leading away runoff water, etc. (Sweden)

An example of groundwater protection with sealing is shown in figure 9. The sealing can e.g. be made by bentonite mat or soil, plastic foil and bitumen membrane, or soil sealing.

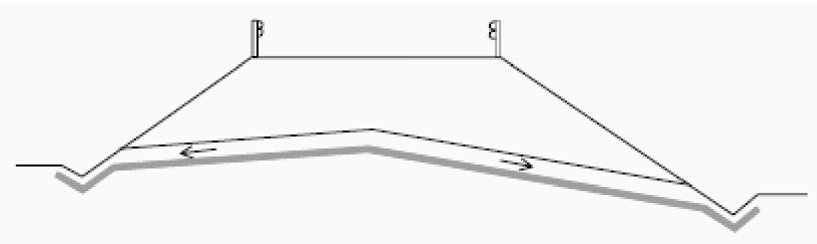

Figure 9: Groundwater protection beneath an embankment. From Finnish standard.

Water seeping through the pavement, might also pick up pollution from the pavement materials. Nine countries answer that they for this reason are prevented in using certain materials:

- Materials can be used if they do not give problems with recycling, destruction or other environmental aspects (Sweden)
- All materials hazardous to groundwater and soil must not be used (Croatia)
- The UK has standards regarding materials that should be prevented; (HA/Standards/MCHW/DMRB)
- All industrial by-products need a permission from environmental authority (Finland)

- The materials have to be tested for their use in the environment, only limited emissions of DOC and heavy metals are allowed (Germany)
- Organic materials cannot be used (Virginia)
- Phosphogypsum / radioactive material is forbidden (Romania)
- The use of hazardous materials is forbidden. For other materials, no particular regulation. For the specific case of MSWI bottom ash, an assessment of the leaching potential is carried out prior to use: above some threshold values, the use is not recommended. It is not a regulation but simply a memorandum of the ministry of Environment (France)
- Materials as e.g. gunite cannot be used to stabilize embankments. This is mainly for aesthetic reasons though, since it is not possible to restore it (with plants, grass etc). Environmentally friendly material (e.g. jute) is preferred to stabilise an embankment (Greece)

The following table gives an overview of the number of countries having special construction requirements due to the type of material used in the construction.

Construction requirements are dependent on following factors		
Factor	**No. of Countries having requirement**	**Dependency**
Type of material	5	- Seepage water from by-product layers must be controlled, at least by coating. Usually also the seepage water has to be collected and discharged/piped separately through communities. Still they have to be monitored (groundwater from standpipes, sometimes also wells). Typically, some soil samples are also analysed. By-product layers are not allowed at groundwater catchment areas. (Finland) - Construction requirements are described in HA Standards/MCHW/DMRB (UK) - By-product layers are not allowed at groundwater catchment areas. Dependent on the embankment material, drainage and sometimes sealing is necessary (Germany) - Romania has specific technical recommendations for the construction of embankment from fly ashes, slag, etc - For all materials, the usual characterisation of engineering properties applies to all materials. For the specific case of MSWI bottom ash, in addition to this, some recommendations are provided (France).

France is a good example of how guidelines to the use of by-products can be set: In order to prevent against potential environmental problems due to MSWI bottom ash use in road construction, a set of guidelines was written by the French Environment Ministry in 1994, via a

memorandum (Ministère de l'Environnement,1994). In Appendix III of this document, three categories of material ("V", "M" and "S") are distinguished according to both the unburned fraction and leaching potential: Soluble fraction as a whole (in % of dry material), and specific leached amount of Hg, Pb, Cd, As, Cr_{VI}, SO_4^{2-} and TOC (each in mg/kg of dry material). The leaching test protocol follows the 1992 NF X31-210 Standard (AFNOR,1992), which has since been replaced by European Standard EN12457-2 (2002).
According to the memorandum, only those materials belonging to the "V"category (Unburned fraction and Soluble fraction both < 5%; and for the leachate: Hg < 0.2 mg/kg; Pb < 10 mg/kg, Cd < 1 mg/kg; As < 2 mg/kg; Cr_{VI} < 1.5 mg/kg; SO_4^{2-} < 10 000 mg/kg; TOC < 1 500 mg/kg) are authorized for road applications. In Appendix V, the memorandum provides recommendations for using "V"-type MSWI bottom ash with reference to water protection. MSWI bottom ash cannot be introduced in flood zones and in areas close to protected water supply; furthermore, its application must lie at least 30 meters away from any watercourse. Use is forbidden in filling trenches for creating drainage systems or in trenches with metallic drains.

Performance of the seepage water systems

Most countries use sub-surface drainage systems that collect both water seeping through the pavement, and groundwater rising to the pavement. The sub-surface drainage systems most often combine with the surface runoff and are treated combined, in the ways mentioned in the section on runoff water.

Only one country answers that they check to see that the seepage water system conforms to the regulations. This is the UK, which has the Environment Agency to check the sub-surface drainage system.

Sampling of seepage water

Only Croatia seems to sample seepage water on a regular basis. It is done by the Institution for protection of public health. Other countries only sample for research purposes. Following procedures are mentioned:

- Some research projects collected percolation water near rural highways and heavy traffic loaded motorways during two years. No standards for sampling were followed. The researchers used suction cups with ceramic heads in several depths and distances from the road edge. The samples were stored as for runoff samples (Table 1), but purity of all devices and chemicals is even more important, because the concentrations of pollutants are very low (Germany)
- Samples have been taken 2-3 m under the ditch axis on the selection parts of some roads, four times per year. Sampling is described in the reference Krajaca, J., "Water Sampling", first publishing. Chichester: Ellis Horwood Limited, 1989. (Czech Republic)
- France has in a research project sampled only in a depth of a few centimetres. Sampling has been continuously over one year. The sampling standard RN46 was used, and samples were stored at 4 °C until analysis.

The questionnaires report that the pollutants that give the most problems in seepage water can be prioritised as:

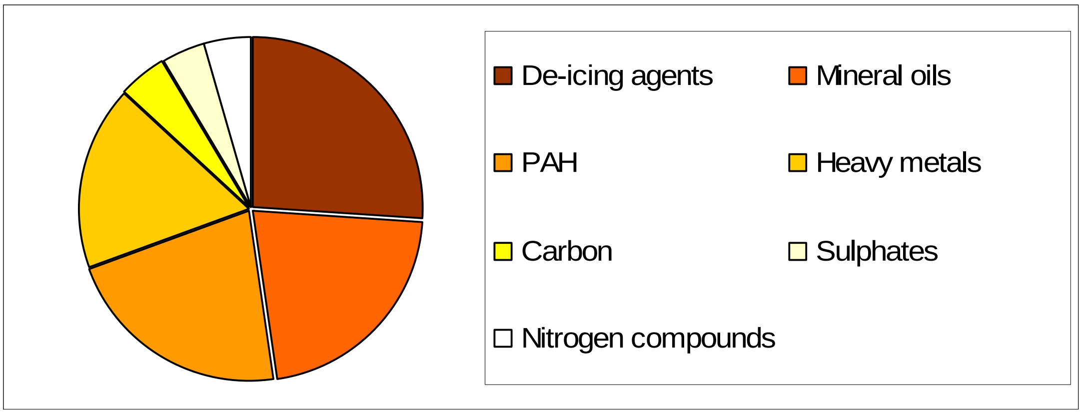

Figure 10: With which pollutants do you have the most problems in seepage water?

It is noted that the question on pollutants has been difficult to answer, because the pollutants in the seepage water depends on the material used in the road construction. I.e. by-products sometimes release sulphates and maybe some metals.

Detecting and rectifying pavement and embankment pollution

Pollution is sometimes differentiated between ambient, road-related and non-road related. The experts answering that they do differentiate, explain how this is done:

- This is extremely difficult. With the exception of herbicides and de-icing agents, most pollutants within the highway environment are sourced from vehicles, although there will be atmospheric deposition. Most of the Highways Agency's network is non-urban. Monitoring sites are chosen carefully to minimise the impacts of adjacent land use in order to get a better picture of road-related pollution (UK)
- Some highly traffic loaded motorways in Germany are being monitored carefully. These sites are situated at rural motorways, the ambient values of bulk deposition are measured also (Germany)
- Isotopes, pollutant rations, atmospheric precipitation and dust monitoring (California)
- With the use of blank sections of roads made with natural material. With soil quality investigations, underneath the road structure and nearby (France)
- In rural areas there is only road-related pollution. Not tested in urban areas (Serbia & Montenegro)
- By observations and specific tests (Romania)
- Checking the existence of other pollution sources and/or analysing rainwater (Portugal)
- With the definition of measurement points in the upgradient and downgradient direction (Slovenia)
- We measure emission, not the immision (Poland)

Slovenia and Poland have routine measurements of road-related pollution once or twice a year on state roads. Most of the other countries have had a number of specific sites that have been monitored carefully to get an idea of the pollution. I.e. the policy in Germany is: It is not necessary to do monitoring at every road. The BASt started a “worst case” monitoring at some heavily traffic loaded rural motorways, which focuses on pollutants from regular traffic. Results from these showcase roads can be used to test and update regulations. Pollutions resulting from accidents are treated together with the local environment authorities. There, an individual plan for remediation and, if necessary, monitoring has to be made, which takes into account the spilled substances and local conditions.

Almost all countries have experienced pollution due to the road construction or the traffic use. Table 2 gives an overview of the actual case stories.

Table 2: Situations with actual pollution due to the road construction, or due to the traffic use.

Country	**How was it observed**	**How was it measured and monitored**	**Counteractions and prevention of further pollution**
California	Monitoring of highway and construction sites in highly urbanised areas compared to other sites.	Grab and composite samples were collected during the rainy seasons and analysed for various constituents.	More resources are devoted to urban construction activities, and a series of "Best Management Practices" are implemented to contain pollutants within the site. Prevention by source control and "proper house keeping".
Croatia	Incidentally observed by road users, or anglers.	By licensed firms or laboratories.	Quickly after accident licensed firm takes action in preventing and stopping further pollution Sometimes changing road geometry or disposition of the road.
Czech Republic	By passive sampling (SPMDs)	By passive sampling (SPMDs), two times per year, it started in 2002.	Concentrations of pollutants are below the limits but with increasing traffic intensity, the concentration of pollutants slowly increase.
Finland	1) Quality of water in drinking wells (monitored routinely in accordance with the reference: http://www.finlex.fi/fi/laki/ … kaannokset/2000/en20000461.pdf) and 2) Strange colour in the snow at the ditch.	Both cases were at by-product locations (slag). 1) From well and observation wells. Maybe some dust of the slag had been spread on the area during construction. 2) Surfacing was delayed, and some rainfall did fall on the open road structure.	It seems that the contents are lowering quite fast with time. The dust and its sulphur, chlorides and aluminium (=>low pH, Al, Mn) have already been washed away. The green colour on the snow/water was told to be temporary and harmless (blast furnace slag sulphur/CaS + water => $Ca(SH)^2$ and polysulfides as CaS4 which may react with metal in oxygen-free (under water) situation and form blue-green metal sulphides, which react with oxygen and form colourless metal compounds, sulphates and sulphites.
France	Seepage colour, plant disease.	Thanks to sampling in ditches, in piezometers.	Pumping, absorbing draining trench. Prevention with surface insulation.
Norway	Dirty snow, increased salt levels.	Project: samples analysed.	Change the strategy for snow dumping / change salting strategy.
Poland			Usage of water runoff refineries (tight drainage, separators, etc.)
Portugal	Due to monitoring.	Field and laboratory studies,	None.

		evaluating runoff and groundwater quality, and the transport and movement of heavy metals in soils.	
Romania	By visually observing the cleanness of the road pavements, from kerosene or oils leaking from traffic, during the routine inspection or learning from the local people along the road route, the quality of the drinking water from their well became deteriorated (infested with de-icing salts, oils, etc.).	By testing the water from the ditches, in parallel with tests of water in the adjacent wells.	Recommending reduction of the de-icing concentrating salts, cleaning the side ditches to prevent water stagnation, recommendation for treating the water from wells, before consuming or to discourage their use, even for watering animals or sensitive plants, initiating or proposing research targeting the finding of non-polluting de-icing, such as vegetal ones or other techniques, capable to eliminate their use in the future.
Serbia & Montenegro	Based on groundwater pollution.	By groundwater sampling and testing	Isolated concrete channels were constructed.
Slovenia	By incident, during groundwater monitoring.	Concentration of chloride and heavy metals	None.
Sweden	Rising chloride-content in drinking water	Monitoring of groundwater chemistry in observation tubes and wells in different depths in the aquifer.	Minimise the use of NaCl as well as technical actions for leading away surface water. Minimise the use of NaCl.
UK	Fish kills in rivers as result of accidental spillages. Source usually obvious, i.e. diesel spillage.		Highways and drainage systems cleaned and restored. Boons used to contain spillage downstream of outfall. Drainage system re-appraised and retrofitted to provide better protection.