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# ENVIRONMENTAL IMPACTS AND BEST MANAGEMENT OF URBAN STORMWATER RUNOFF: MEASURES AND LEGISLATIVE FRAMEWORK

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## ABSTRACT

Urban stormwater runoff constitutes a non-point source pollution, which contributes in degradation of water bodies' quality (USEPA, 2002).

European Union's environmental policy includes water environment protection and preservation by adopting a series of directives, 2000/60/EC (Water Framework Directive - WFD), 97/11/EEC (Environmental Impact Assessment Directive - EIA), 2001/42/EC (Strategic Environmental Assessment Directive - SEAD) and many others. However, such legislative framework is not strongly related to the issue of urban stormwater runoff management, due to its general content.

Pollution control of urban stormwater runoff entails a management strategy based on scientific research and reliable available data. Consequently, the subject of prevention and control of urban stormwater runoff remains still open and it is a motivation for further research and discussion; it also underlines the need to propose detailed specifications both for environmental impact assessment, as well as for the proper formation of a data-base.

Thus, within the content of the present paper, the following are included: a) the investigation and presentation of the receiving waters pollution issues from the urban stormwater runoff, b) the examination of the respective pollutant generation and characteristics, c) the presentation of their impacts d) the examination of the measures (structural and non-structural BMPs) f) the presentation of the existing legislation in the EU and Greece. Finally, specific measures, which authorities must take into account in the framework of the programs for runoff river basin management, according to the 2000/60 EC Directive and the Greek Law 3199/2003, are proposed.

**KEYWORDS**: urban stormwater runoff, water pollution, water quality, best management practices (BMPs), environmental impacts, environmental legislation.

## 1. INTRODUCTION

Urban development of a watershed area involves, firstly, the replacement of vegetation and topsoil by impervious surfaces of parking lots, building tops, sidewalks, paved and cemented roads, etc. and secondly, surface soil compaction. Thus, urbanization makes urban area surface less pervious, causing significant changes in an area's hydrological characteristics (increase in peak flows and runoff volumes, decrease in concentration time). Additionally, during rainfall, raindrops carry along atmospheric pollutants and urban runoff, created this way, is enriched with various particles and pollutants attached to urban surface. As a result of this, polluted urban runoff ends in receiving groundwater and surface water bodies, thus affecting negatively their quality.

Traditional techniques used for runoff concentration estimation are not the best solution to the problem discussed, as they ignore possible environmental impacts, showing emphasis only in flood prevention (Scholes *et al.*, 1998). Today, it is a common belief that urban runoff, as non-point source pollution, contributes in water bodies quality degradation (USEPA, 2002). More specifically, such runoff may have significant environmental impacts, especially in the long-term, since it may transfer various pollutants like heavy metals, solid particulates, chlorides, PAHs etc. These impacts have a direct effect on human beings, as well as on flora and fauna. Flood source control is considered as the only socially, ecologically and economically acceptable solution to mitigate urban runoff impacts, which affect ground and surface receiving waters, ecosystems and human health.

## 2. POLLUTANTS IN URBAN RUNOFF AND FACTORS AFFECTING THEM

Sources of urban runoff are related to untreated wastewater, households, road network, fuel stations, parking lots, golf courts and parks (Burton and Pitt, 2002). However, some other factors also play a crucial role in urban runoff pollution: atmospheric pollutants deriving from urban transport and deposited in urban surface; pollutants deposited in surfaces like roads, roofs and parking lots; pollution deriving from construction fields; the use of pesticides in parks and green space; and de-icing materials used in roads during winter. The most important pollutants, included in urban runoff, are sediments, nutrients (nitrogen and phosphorus), chlorides, heavy metals, diesel hydrocarbons, microbial pollution, organic compounds and litter. The type and concentration of urban runoff pollutants vary in different areas and depend upon land-use specific characteristics: housing, commercial and industrial facilities, as well as, economic activities in a watershed define the exact form of pollution in urban runoff (Shaver *et al.*, 2007). Generally, the concentration of pollution is related to urban surface characteristics and wet and dries atmospheric depositions (Förster, 1999). Urban surface characteristics refer to surface materials, type and degree of urbanization, local climate conditions, road slopes and area relief, and orientation and spatial placement of urban area within the watershed (Göbel *et al.*, 2007).

Due to atmospheric pollutants' depositions on impervious surfaces, accumulation of pollutants takes place. Barret *et al.* (1998) mention that there is a strong relation between pollution concentration and traffic volumes, whereas Aldheimer and Bennerstedt (2003) conclude on the necessity of urban runoff water treatment of roads with a daily average traffic volume of more than 30,000 vehicles, before runoff ends in water bodies.

Roof condition and construction materials are the most important factors related to urban runoff pollution deriving from roofs. Roof runoff may include suspended solids and trace metals. Pollution concentration is also dependent upon roof condition, construction materials and local climate conditions. In New Zealand, for example, many buildings are constructed in coastal areas, enhancing faster roof corruption, due to materials' corrosion (Gadd and Kennedy, 2001).

Ice melting, especially when combined with rainfall, is responsible for pollution generation, chlorides and de-icing materials. It is also underlined that runoff volume in such a case may be greater even than a summer storm because of simultaneous rainfall and ice melting phenomena (Oberts, 1994).

The use of pesticides, herbicides and fertilizers in parks and open green space in urban areas is responsible for pollution of water bodies, especially by nutrients. Although the quantity used is usually small, pollution concentration may be high in water bodies (Revitt *et al.*, 2002). Transport of pollutants is dependent upon rainfall characteristics, the time between the use of pesticides and rainfall and the specifications of each pesticide (Aldous and Turrell, 1994).

Animal feces in urban environment (pets and birds) are an important source of microbial pollution of urban runoff. Another source of microbial pollution consists of septic systems and illegal sewer connections. Young and Thackston (1999) note that, bacteria concentration in urban runoff is related to watershed elevation and the percentage of impervious watershed surface. Nevertheless, microbial pollution is higher in warm months and lower during colder months.

Construction sites in urban areas contribute to pollution in urban runoff, as they are responsible for the biggest part of sediments in runoff. This is related to high percentage of soil erosion, due to absence of vegetation (Johnson and Juengst, 1997). Soil erosion depends upon local conditions, rainfall, soil and area topography (NRC, 2008). Construction fields' runoff may include total suspended solids (TSS) of 3,000 to 7,000 mg/l (Shaver *et al.*, 2007).

According to Bochis and Pitt (2005), water quality problems are increased in case of increased impervious watershed surface, as impervious surface is responsible for increased runoff and higher level of pollution.

In Table 1 major and minor sources of pollution in urban runoff are summarized (http://www.geog.Leeds.ac.uk/projects/nps/reports.htm), while M=Major source and m=minor source.

## 3. IMPACTS OF URBAN RUNOFF IN WATER BODIES

Urban runoff may affect negatively water bodies' quality and also transfer pollutants to groundwater, due to percolation. Surface water bodies may be directly affected by runoff pollution or indirectly by sewerage systems, while groundwater is affected by percolated runoff, taking into account the ability of soil to filtrate runoff and contribute to diminishing pollution load. It should also be underlined that there is also interaction between surface water bodies and groundwater, which is related to pollutants transfer (Göbel *et al.*, 2007).

Urban runoff ending in surface water bodies (lakes, rivers, etc.) may cause biological integrity elements' degradation: it is possible to provoke negative impacts to entire ecosystems, including water quality, bottom sediments, aquatic life and habitats (Pitt and Bozeman, 1982).

According to Schueler (1987), the combination of factors such as sedimentation, leaching, increase in flooding phenomena, lower runoff in summer and higher water temperatures, is responsible for water quality bodies' gradual degradation and not only one factor by itself.

*Table 1*. Several pollution sources in urban runoff

| **Sources** | **Pollutant** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Sediment** | **N** | **P** | **Pathogens** | **Cu** | **Zn** | **Pb** | **As** | **Cd** | **Trace metals / inorganics** | **Pesticides and biocides** | **Hydrocarbons / PAH's** | **Persistent organics** |
| Atmospheric deposition | **M** | **M** | | m | | | | | | | | | |
| Fossil fuel emissions | m | **M** | | | | | | **M** | | | | **M** | |
| Vehicle emissions | | **M** | m | | | | **M** | | | | | **M** | |
| Vehicle wear | m | | | | **M** | **M** | | | m | **M** | | **M** | |
| Road abrasion | | | | | | | | | | | | **M** | |
| Road maintenance (f.e. de-icing) | m | | | | | | m | | | m | m | | |
| Soil erosion | **M** | m | **M** | m | | **M** | | | | | | | |
| Construction sites | **M** | | m | | | | | | | | | | |
| Industrial waste | | | m | | | m | m | | **M** | **M** | m | **M** | **M** |
| Roof and other surface abrasion | m | | | | | m | | | | | | | |
| Garden, parks and trees | m | **M** | **M** | | m | m | | m | | | | **M** | m |
| Animal wastes | | **M** | **M** | **M** | | | | | | | | | |
| Other wastes and spills | | | | m | | | | | | | m | m | m |

Urban runoff may also be responsible for human loss, private property disaster, public infrastructure destruction (bridges, roads, etc.) and they may cause: (a) landscape impacts related to excessive sediment deposition, (b) increase in water loads in streams during rainfall, (c) eutrophication due to increase in nutrients (nitrogen and phosphorus), (d) turbidity, related to eutrophication or sediments and (e) increase of heavy metals in water bodies (Pb, Zn, Fe, Cu, Cd, Cr, Ni, etc.).

## 4. LEGISLATION IN FORCE IN THE EU AND GREECE

There are many Directives in the EU related to water environment protection and the most important is 2000/60/EC Directive (incorporated in national law by virtue of Law 3199/2003 and the Presidential Decree 51/2007), which determines the framework of community action in the sector of water policy and defines integrated water resources management in watershed level. However, the Directive involves a general content for water protection (inland surface, transitional, coastal waters and groundwater), while there is no reference in non-point source pollution deriving from urban stormwater runoff (Yannopoulos *et al.*, 2006a; 2006b).

The institution of Environmental Impact Assessment (EIA), as implemented in the EU, is one of the most important instruments for implementing pollution prevention principle and promoting sustainable development. By EIA it is ensured that environmental impacts (direct-indirect, significant or not, positive-negative, reversible or irreversible, etc.) are taken into consideration while designing a proposed project or development action (Yannopoulos *et al.*, 2009). For EIA the Directive 97/11/EC (EIA Directive) has also been enacted, which generally refers to impact assessment of proposed projects on the environment and the Directive 96/61/EC (Integrated Pollution Prevention and Control Directive - IPPC) for industrial pollution prevention and control. However, both Directives are not relevant to urban stormwater runoff management. Although EIA is recognized as one of the most important tools for promoting sustainable development, the lack of data and specific legal framework creates problems in its implementation on urban stormwater runoff management. Greek national legislation has been harmonized with European legislation, with Law 1650/1986, Law 3010/2002 and a number of Joint Ministerial Decisions (JMD), for example JMD 69269/5387/1990, JMD 75308/5512/1990, JMD 15393/2332/2002, JMD 11014/703/F104/2003 and several others (Yannopoulos *et al.*, 2006a). Changes in Greek environmental legislation, related to EIA, have been introduced by the Law 4014/2011 and Ministerial Decisions (MDs) 1958/2012 and 20741/2012 (replacing the JMD 15393/2332/2002), as well as by many other MDs of the year 2012.

The main EU legislative document for urban runoff control is the Directive 91/271/EEC (Urban Wastewater Treatment Directive - UWWTD), whose primary objective is to protect the environment from negative impacts, caused by disposal of untreated or inadequately treated wastewater and sludge, as well as industrial wastewater discharge in urban sewerage systems. The Directive, which has been transferred to national law by our JMD 5673/400/1997 is related to domestic sewage, a mixture of domestic wastewater with industrial and rainwater, and does not address the subject of urban stormwater runoff treatment.

The EU adopted the Directive 2001/42/EC (Strategic Environmental Assessment Directive - SEA), in an effort to consider environmental impacts of plans and programs, which provide the necessary framework to carry out several proposed projects and activities. The Directive 2001/42/EC was transferred to national law by JMD 107017/2006.

In Greece, the legal framework related to spatial and urban planning refers to: (a) Law 2508/1997, which sets out the guiding principles, conditions and procedures of urban planning and sustainable development of residential areas, cities and settlements in the country and (b) Law 2742/1999, concerning planning and sustainable development. According to JMD 15393/2332/2002 and Law 3010/2002, urban planning studies are subject to Environmental Impact Assessment, while according to the JMD 107017/2006, Strategic Environmental Assessment studies are required for all planning studies of Law 2508/1997 and Law 2742/1999, such as Municipal Planning Studies, Regional Planning Studies, Special Frameworks for Spatial Planning and Sustainable Development etc. The Ministerial Decision 9572/1845/2000 that presents the technical requirements of Municipal Planning Studies mentions that planning studies should include a general environmental impact appraisal of all proposed scenarios, so as to choose the proposed scenario involving the least impacts. However, in legislation related to spatial and urban planning, there is no reference to prevention pollution from urban stormwater runoff, although contamination is significant as we have already mentioned.

At this point it is also underlined that in order to assess the environmental impacts on water bodies from stormwater runoff in urban areas, knowledge runoff characteristics (concentrations, level of pollution, physical and chemical processes, etc.) is essential, though such data hardly exists in most EU countries and in Greece.

## 5. METHODS OF URBAN RUNOFF MANAGEMENT

The adverse effects on water bodies from urban stormwater runoff may be minimized by several techniques that are referred to as Best Management Practices (BMPs). They involve a construction, a technique or a method whose objective is the removal, reduction, delay or prevention of substances, pollutants and contaminants in stormwater runoff, before it reaches water bodies (Strecker *et al.*, 2001). Generally, there are two types of BMPs used to minimize pollution from stormwater runoff: (a) structural BMPs and (b) non-structural BMPs.

### 5.1 Structural Best Management Practices

The purpose of structural BMPs is to trap runoff physically until pollutants settle down or get filtered by existing soil layers. The basic mechanisms of pollutant removal techniques are precipitation, filtration of soluble nutrients through soil or special filters, and chemical or biological processes. Generally, structural BMPs may be considered as measures that slow down, retain or absorb pollutants that are carried away and transported by stormwater runoff (Yannopoulos *et al*., 2006a). Some of the most commonly-used structural BMPs are: (a) vegetated systems (filter strips, grass swales); (b) infiltration systems (infiltration basins, infiltration trenches, bioretention systems, sand filters, dry wells); (c) storage facilities (detention ponds, wet ponds, constructed wetlands, green roofs) and (d) pervious paving systems (porous paving, porous asphalt, whisper concrete), as described below (Yannopoulos *et al.*, 2012):

#### *5.1.1 Vegetated systems*

In vegetated systems filter strips (or filter strips or buffer zones) and vegetated swales are included, presented as follows:

- Filter strips demand much more surface related to other BMPs and they are effective in waste removal. They can be implemented in most cases but in some cases this is not feasible due to the fact they need more space compared to other BMPs. These strips are suitable for runoff from urban streets and boulevards, roofs, small parking areas and impervious surfaces. They are an exceptional solution for the protection of cold water streams since they do not increase the water temperature of stormwater runoff. They are not the best solution for urban areas with high building density and few impervious surfaces. On the contrary, they are an ideal solution for pre-treatment of urban runoff before their treatment with other BMP (CSQA, 2003).
- Vegetated swales may be dry or wet and they transport urban runoff and enhance processes of infiltration and decrease in flow rate. Dry vegetated swales are used in areas where standing water is not desired (e.g. residential areas), while wet vegetated swales are used where standing water does not cause a disturbance, in areas that intersect groundwater levels or in soils that have low percolation rates (USEPA, 1999a). Vegetated systems are usually placed next to roads and they are more effective when they have small slopes and slightly inclined banks. They are ideal stormwater runoff drainage systems in industrial areas due to the fact that the pollution transported is visible (Woods *et al.*, 2007).

#### *5.1.2 Infiltration systems*

Infiltration systems are designed in such a way that they can trap runoff and then filter it in the ground. These systems provide efficient removal of suspended solids, particulate pollutants, coliform bacteria, organics and some soluble forms of metals, and nutrients from stormwater runoff. The captured runoff increases groundwater recharge and base flow in nearby streams (USEPA, 1999b). Their disadvantages include the risk of reduced infiltration capacity or even of the obstruent capacity due to excess accumulation of sediments. In this case, there is need for frequent maintenance. Infiltration systems comprise infiltration basins, infiltration trenches, bioretention systems, sand filters and dry wells, presented as follows:

- Infiltration basins are not suitable for areas where high concentration of pollutants or sediments is expected, due to the probability of groundwater contamination. Especially, they are not suitable for industrial and commercial areas where oil products and pesticides are loaded and uploaded in the framework of the freight transport system operation. The same also applies in the case of areas where dangerous materials exist, areas with high risk of leak of toxic materials like gasoline stations and car maintenance installations (NJ Manual, 2004). Infiltration basins are suitable for areas with highly permeable pervious soils.

- Infiltration trenches are usually designed for the first flush of a rainfall event and that is why they are used together with other BMPs, such as detention ponds (USEPA, 1999). Infiltration trenches are inappropriate solution for areas where chemicals or dangerous materials are stored unless there are special provisions for such materials (CSQA, 2003).
- Bioretention systems or rain gardens operate several mechanisms for pollutants' removal and thus, they are an excellent BMP (Debo and Reese, 2003). They may be implemented even in simple cases e.g. at a residence, at parking lots, next to the road network and at regenerated areas with impervious surfaces. The implementation of these systems is not feasible in areas with clay concentration higher than 25%, in areas with slope more than 20% and in areas where big trees have been cut down. They are especially suitable for areas with clay soil (CSQA, 2003).
- Sand filters are very suitable for urban and residential areas (EPA VICTORIA, 2005). In general, they are preferred from other techniques e.g. bioretention systems, at areas where groundwater pollution by conventional pollutants needs much attention. Sand filters are implemented in areas with high pervious percentages and high percentages of TSS, hydrocarbons and heavy metals like roads, parking places and high density urban areas (NJ Manual, 2004). Their use may be limited by their cost and their maintenance at the installation area (Debo and Reese, 2003).
- Dry wells are not suitable for areas where high concentration of sediments or pollutants in general is expected, because of the probability and the risk of groundwater contamination (Revitt *et al.*, 2003). They can be applied in single-family housing for the purpose of stormwater runoff management from the roofs. They may also be used to parking areas. But in this case, "greater care is needed to ensure that sediment and pollutant levels are reduced to acceptable levels before passing flow to the device" (Woods *et al.*, 2007). Another use of dry wells has to do with management of overflow from other BMPs systems (Woods *et al.*, 2007).

### *5.1.3 Retention/detention systems*

Retention/detention systems are designed in order to capture some quantity of stormwater runoff and to temporarily store water. This water is then gradually released to a water receiver or to the rain water sewer system. These systems involve detention ponds, extended detention ponds, "wet" ponds, constructed wetlands and green roofs, presented as follows:

- Detention ponds and extended detention ponds are mostly designed for runoff volume management, however, they ameliorate runoff quality, by sedimentation of a great part of suspended solids. Construction cost is lower in comparison to costs of other detention practices, but maintenance costs are significantly higher. They may be used in areas where a great increase in runoff volume is expected, due to urban development (NJ Manual, 2004).
- "Wet" ponds or retention ponds are used in small sewered surfaces and they are extremely suitable for residential areas and areas with high concentration of nutrients expected (e.g. golf courts) (CSQA, 2003).
- Constructed wetlands need a surface of 3-4 times more than any other BMPs and that is why their construction cost is higher. Wetlands cannot be constructed in sandy soils, high-pervious soils and in areas with high evapotranspiration rate (Schueler *et al.*, 1991).
- Green roofs are designed in order to stop and retain precipitation, decrease runoff volume and maximum flow (Woods *et al.*, 2007). In relation to other BMPs, they have an important advantage of not demanding urban surface. Pollutants' removal at green roofs increases with time and their best efficiency is reached at five years after their construction (PEC, 2006).

### *5.1.4 Pervious paving systems*

Pervious paving systems refer to surfaces with materials that generate less urban runoff than surfaces covered with conventional materials (asphalt, concrete, paving, etc.). Decrease in runoff volume is achieved mostly by infiltration of the greatest quantity of precipitation through cover materials or empty space left between cover materials. Such systems are used in gardens, pedestrian streets, roads and parking lots (NJ Manual, 2004). However, their use is restricted to cases where traffic is characterized by passenger cars and light trucks due to the fact that their surface layer is of limited resistance.

### *5.1.5. Criteria for the selection of the most appropriate BMPs*

In a specific urban runoff management scheme several structural BMPs may be used. The choice of appropriate BMPs results from considering several parameters and depends on the area's characteristics. Each area is a special case and this is why not all structural BMPs are suitable for all areas. In general, criteria to chose among appropriate structural BMPs depend on climate, geographical and economic parameters, the runoff volume expected, the types and concentration of pollutants, the available urban surface, the natural environment of the area, etc. (Yannopoulos *et al.*, 2012).

The basic criteria that should be taken into consideration for the appropriate structural BMPs choice are described as follows (Woods *et al.*, 2007): (a) land-use patterns (residential, commercial area, construction density, road network, areas for new urban development etc.); (b) several characteristics of the area (soil permeability, catchment surface within urban area, minimum depth of groundwater, available space for BMP construction, etc.); (c) quantity and quality structural BMP effluent demand (capability to remove pollutants and decrease volume runoff, etc.); (d) social and ecological demand (social acceptance, maintenance, costs, creation of habitats etc). According to Woods *et al.* (2007), the basic design principle of an urban runoff management system is "effective stormwater drainage for the protection of public health and security, as well as the environment". Thus, before the final decision for urban runoff management, it is necessary to look at the effectiveness of all structural BMPs for the area of study, by evaluating their output, maintenance, advantages and disadvantages for their implementation in the specific area of study (MWCOG, 1992).

From several studies conducted, the following remarks are made (Revitt *et al.*, 2003): (a) infiltration systems, vegetated swales and detention ponds are better in comparison to other structural BMPs for their technology and viability; (b) vegetated filter strips have a better output as far as groundwater enrichment and pollutants' removal; (c) and constructed wetlands, retention ponds and extended retention ponds appear to have the least natural restrictions in their use.

### 5.2 Non-structural Best Management Practices

The non-structural BMPs involve preventive actions that do not include structural solutions, but rules and regulations, which aim to prevent or restrict pollutants' load in stormwater runoff (Taylor and Wong, 2002). Non-structural BMPs focus on control measures, while structural BMPs provide with solutions by addressing problems after they have occurred. In many cases, it is obvious that pollution prevention seems to be easier and more efficient than trying to tackle pollution after it appears. Non-structural BMPs are usually more economically efficient, as they are strongly to prevention and not mitigation (Yannopoulos *et al.*, 2006a). However, it is preferable in most urban runoff management plans to use a combination of structural and non-structural BMPs to achieve better results.

The use of non-structural BMPs may ameliorate operation of structural BMPs, as well as decrease maintenance demands. Consequently, an integrated system for urban runoff management should incorporate both structural and non-structural BMPs. Some of the most commonly-used non-structural BMPs are: (a) streets' cleaning, (b) reducing the use of polluting substances, (c) public environmental awareness, (d) control of impervious surfaces construction, (e) implementation of flood prevention techniques, (f) recycling and waste disposal programs, (g) land-use planning and planning management strategies and (h) control practices at source.

## 6. CONCLUSIONS

Urban stormwater runoff, as a non-point pollution source, contributes to water bodies quality degradation, both in groundwater and surface waters. The EU has integrated its environmental policy to protect and preserve the interior, surface, transitional waters, coastal waters and groundwater by publishing a series of Directives. However, the legislative framework (Directives 2000/60/EC, 91/271/EEC, 97/11/EC, 96/61/EC, 2001/42/EC etc.) is general and not relevant to effective urban stormwater runoff management. Environmental Impact Assessment is one of the most important tools for promoting sustainable development, although lack of data and specific legal requirements create problems in the implementation of urban stormwater runoff management plans.

It is also mentioned that in order to assess the environmental impacts on water bodies from stormwater runoff in urban areas, knowledge runoff characteristics (concentrations, level of pollution, physical and chemical processes etc.) is essential, though such data hardly exists in most EU countries and in Greece.

With BMPs treatment of urban stormwater runoff can be achieved by as close as possible to the source, reducing runoff volume by temporary storage and then disposal of stormwater at a controlled rate in soil, water bodies or sewage systems. With the use of BMPs the urban environment may be improved, because of their versatility and multifunctional role (e.g. a retention basin can be used for storing rainwater, but also as habitat of wild fauna).

In Greece, the legal framework related to planning (Law 2508/1997, Law 2742/1999 and MD 9572/1845/2000) and environmental assessment (Law 1650/1986, Law 3010/2002, Law 4014/2011, JMD 107017/2006, etc.) does not include the aspect of pollution management from urban runoff, while very few studies have made a reference to the quality of urban runoff (Akratos *et al.*, 2004). There is also little experience with the implementation of BMPs, since the only known cases involve Athens Airport “Eleftherios Venizelos”, the Olympic Rowing Centre at Schinias and the National Road in Korinthos. Generally, the reasons for preventing the implementation of BMPs in Greece are the lack of an appropriate legal framework and technical standards, the depreciation of environmental impact assessment, lack of data, the difficulty of appropriate research funding and people’s reluctance to cover the relevant cost.

Consequently, in Greece there should be an effort to tackle pollution deriving from urban stormwater runoff. Some of the proposed measures may involve: (a) completing the legal framework and specifications according to a policy for sustainable management of rainwater at a country level, (b) funding of research on BMPs, (c) conducting pilot projects by authorities related to stormwater management (Department of Environment, Energy and Climate Change, Municipal Water and Sewage Company and Municipalities), (d) public involvement on urban runoff management, (e) technically supporting properties’ owners, who wish to implement rainwater collection techniques, (f) the obligation of households to pay connection fees to sewerage systems, (g) providing with available space for BMPs sites in future urban areas, by effective urban plans and (h) designing and constructing drainage networks, in order to be established together with a strategic stormwater runoff management plan, which will consider the possibility and feasibility for control runoff practices at source.

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