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## **Treatment Solutions for Rainwater Contaminated with Various Pollutants**

*This study presents aspects on the environmental pollution with contaminants difficult to manage from sources such as car parking, roads and roofs in crowded areas that have deficient wastewater harvesting urban networks. The contaminants washed by the rainwater that are not collected and treated can reach directly into the natural environment. Thus, rainwater which falls on rough surfaces, especially in car parking and roads without drainage channels carries out various pollutants directly into the soil and water. In order to control environmental pollution there are presented solutions for contaminated rainwater de-pollution.*

**Keywords:** *rainwater, pollutant, sewage system, filtration substrate, gutter*

### **1. Introduction**

The issue of environment pollution is often approached by experts through various theoretical and experimental subjects. Generally, environmental protection measures aim at restoring or remedying local effects, but in a sustainable and efficient approach, some of the causes of pollution can be eliminated.

The effect of discharging into the environment of chemical compounds from various sources that are washed by rainwater, is on the one hand the occurrence of acid rain, and on the other hand the soil and water pollution. By taking chemical pollutants by municipal sewer networks, especially those designed in an integrated system is an expensive solution from cleansing in treatment plants point of view [1].

The pollutants that are found in wastewater draining systems are:

- Sediments: particles transported from various sources;
- Biochemical oxygen demand;
- Materials that deplete oxygen;

- Leaves;
- Organic materials;
- Toxins:
  - Pesticides (herbicides, fungicides, insecticides);
  - Metals (naturally occurring in the soil due to vehicle emissions during their operation): lead, zinc, mercury;
  - Petroleum hydrocarbons (fuel and oil from cars).
  - Residues: garbage and illegal waste;
  - Nutrients (different types of materials dissolved or suspended in water mainly from fertilizers used for plants): nitrogen and phosphorus;
  - Pathogenic bacteria: organic matter from domestic animals, migratory water birds, nonexistent septic systems;
  - Heat stress: heat water leaks, water course removal in areas with vegetation.

The water and soil pollution sources can be grouped into two categories:

- Punctiform sources, which are local discharged from plants or at the wastewater discharge;
- Non-punctiform sources, representing agricultural and rainwater leakage.

Over time, there were conducted researches regarding water quality impairment and as a result it was highlighted the negative influence of various activities on pH, water conductivity, concentrations of toxic metals with high impact on living organisms [2], [3].

The water pollution represents the contamination of natural water bodies with chemical, physical, radioactive and pathogenic substances [4].

The activities carried out by people are responsible of chemical pollutants discharged into the natural water bodies. Heavy metals are the result of mining activities [2], nitrogen and radioactive substances (phosphates) of farming and road traffic, copper, lead and zinc of road traffic sector, chlorides of water treatment plants [6], [3] and wastewater treatments and acids discharged from other various activities. In order to protect the environment, the conditions in which wastewater can be taken over by effluents are established by law [7].

The pollutants discharged from punctiforme sources cause thermal pollution that negative affect the aquatic fauna.

The pathogenic microbes that affects the sample bodies are mainly due to the untreated wastewater and agricultural and zoo technical units.

## **2. The groundwater and soil pollution from non-punctiforme sources**

The groundwater quality class and especially of the surface waters is significantly influenced by the pollutant presence and its percentage annual increase.

The main factors that contribute to the pollutants percentage increase in ground-water and soil are the road traffic and industrial sector. As industrial sector is a pollution punctiform source, the pollution control can be achieved by applying local solutions. Regarding the road traffic, this remains a water and soil pollution source hard to control. Rainwater falling on rough surfaces, such as: paved roads, roofs and car parking's, are not absorbed by the soil and therefore they wash wastes from these surfaces after which are drained through sewer systems or directly in the natural environment.

Wastewater treatment methods are chosen based on their characteristics, but for the wastewater generated from the pollutants washed from the hard surfaces, treatment methods appliance involves investments in urban infrastructure. Pollution from non-punctiform source cannot be traced due to the fact that there is no wastewater direct draining point and therefore they do not enter into the treatment plants.

Thus, the road traffic is responsible not only for air pollution [8], [9] but also for water and soil pollution. Therefore, the road vehicles as traffic participants can be considered both punctiform and non-punctiform sources due to their various chemical compounds from burned petroleum products exhausted during operation. The chemical compounds from the fuel (gasoline, diesel) and carbon molecules from lubricates exhausted by vehicles during their operation together with methanol and ethanol contained in the windscreen cleaning solutions washed by rainwater, are all soil and water significant pollution sources.

The petroleum compounds form at soil level an impermeable film which prevent the gases exchange between air and soil and the normal water recirculation.

Gasoline and diesel which are the most commonly used fuels for road vehicles are generally obtained by processing petroleum, being petroleum fractions consisting of mixtures of hydrocarbons. Thus, gasolines and diesel consist of saturated, aromatics and unsaturated hydrocarbons, organic sulfur compounds, nitrogen and oxygen with different percentage content. On the other hand, the exhausted into traffic gases contribute to the increase of the atmosphere acidity and to tropospheric ozone formation with direct and / or indirect effects on water and soil.

A part of chemical compounds dissolved in the rainwater is the result of water passing through the atmosphere. The heavy metals contribution to the water and soil pollution during dry weather is due to compounds deposits from exhausted gases, brake plates dust, rubber and asphalt wear.

Even if the pollutants quantities from road vehicles, collected by rainwater from roadway surfaces and car parking are not very high however, it must be emphasized that the transfer of soluble hydrocarbons derived from residual petroleum products in water becomes more significant especially during heavy rains. Under aerobic conditions, degradation rate of petroleum pollutants reaching the soil depend on the soil temperature, humidity and pH.

### 3. Contaminated rainwater depollution solutions

Generally, unorganized pollution sources are characterized by a composition diversity (organic or mineral suspensions, pathogens, parasites and toxic substances) and low flows. They produce a diffuse pollution, difficult to control and to solve.

Rainwater can be classified as pollutant or un-pollutant depending on their effects on the collector surface nature, but also on the receiving environment. Depending on the substances driven from the collecting surfaces the rainwater pollution level can be determined. If there are physical, chemical or biological changes of the receiving environment, then rainwater usually gravitationally drained are considered as being pollutant. Although gravitational sewage systems are considered to have high efficiency, however the process by which the various pollutants are collected and driven is not sufficiently well studied from theoretical and experimental point of view [10].

The non-punctiform sources control firstly involves viable management solutions in all areas considered as pollutants generating sources.

Global concerns regarding the concept of a sustainable society is an increasing challenge, which also involves resolving the waste issue of any nature. In this sense, the solid and liquid waste recovery is presented as an economic alternative and environmental benefit, the energetic potential of these wastes in areas characterized by large urban agglomerations being assessed [11].

The researches concern for recovery of solid and liquid waste generated by consumers in the residential, tertiary and industrial sectors are described and analyzed in many scientific publications, beginning from the 90's [1], [11], [12], [13], [14]. The optimization of depollution solutions for contaminated areas with pollutants resulted from petroleum products are analyzed by simulations and experiments on case studies [13].

All these aspects are sufficiently analyzed and tested, but the problem of rainwater washing wastes from rough surfaces is not sufficiently resolved, as it is shown in Fig. 1



**Figure 1.** Rough surfaces from which the rainwater collects pollutants

Therefore, a sustainable development involves large investments in infrastructure. Romania has made progresses in the advanced equipment and technologies implementation for domestic and industrial wastewater treatment, which led to environmental pollution considerable decrease [1]. However, large urban agglomerations still have deficitary utility networks, parking areas without drainage channels and hydrocarbons separators, asphalted roads with pot holes, cracks and without drainage channels (Fig.1.c), rainwater collection systems with uncontrolled drain from buildings roofs.

All these shortcomings lead to gradual degradation remediable with high costs, or even irreparable degradation of buildings, roadways and sidewalks, and to the soil pollution increase together with surface and groundwater quality decrease (Fig. 2).

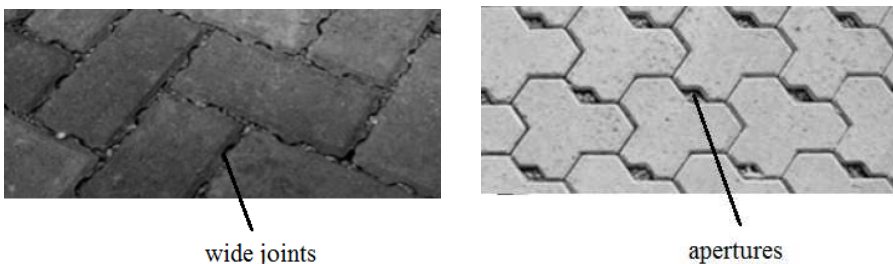


a) building degradation      b) roads degradation      c) sidewalks degradation

**Figure 2.** Negative effects caused by uncontrolled rainwater

Whenever possible, the rainwater must be collected in storage tanks and subsequently recovered and used as wash or irrigation water.

If the rainwater collected from the buildings and their landscaped areas cannot be used as wash or irrigation water it is necessary to analyze the possibility of their infiltration into the soil. Periodical streets cleaning reduce the chemical sediments and wastes discharged into the sewer system during rainfall.



**Figure 3.** Permeable pavements

Regarding the urban rainwater control, the most common solutions are minimizing and avoidance the waterproof surfaces extension, the permeable pavements utilization, especially in order to facilitate the rainwater infiltration into the soil with environmental benefits. These paving material acts as a filter. Penetration of sediment and pollutants into the soil is eliminated, which reduces the damage risk on water quality. Permeable pavements can be monolithic or modular, with wide joints or apertures (Fig. 3).

Recent researches have highlighted the disadvantage of this solution, namely that there is a clogging risk which reduces infiltration capacity [15].

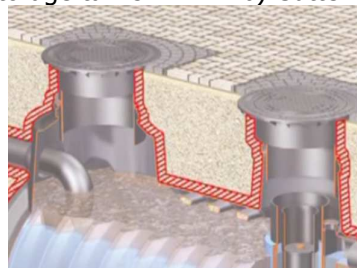
Among the most efficient depollution systems of contaminated rainwater which are uncontrolled drained into the environment there are the underground storage tanks (Fig. 4a), draining gutter with filtration substrate (Fig. 4b) and hydrocarbon separators (Fig. 4c).



a) Underground storage tanks



b) Gutter with filtration substrate



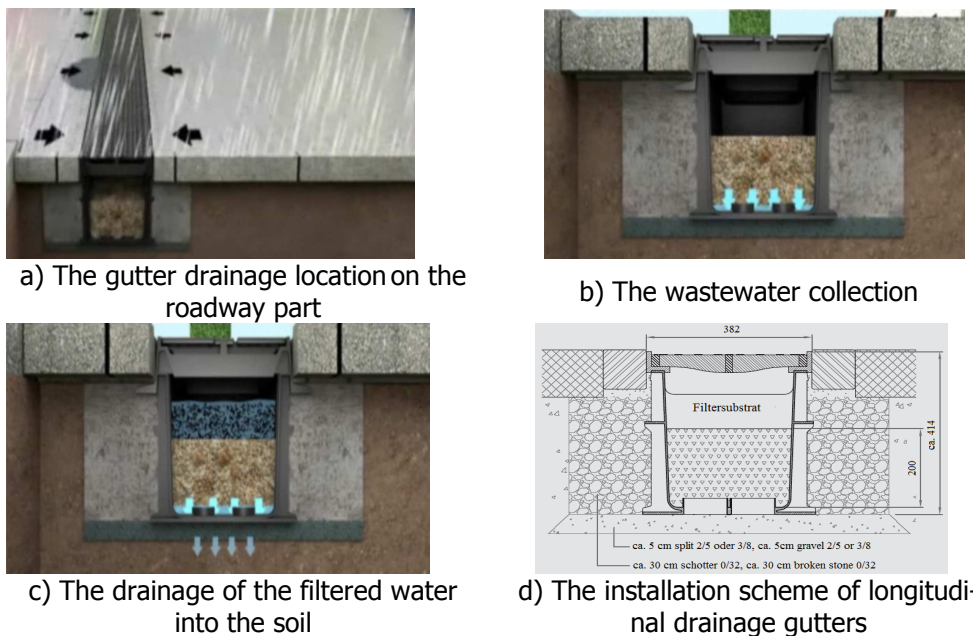
c) Hydrocarbon separators

**Figure 4.** The depollution and drainage systems for rainwater  
(Source: <http://www.funkegruppe.de>, <http://www.kessel.ro>)

Underground storage tanks combine the high storage capacity with a good stability for installation even in areas with low permeability.

This system collects rainwater from roads, car parking and generally from rough surfaces, which are subsequently drained through pipes to wastewater treatment plants. Because they involve large surfaces and infrastructure changes, these systems are suitable for local applications.

Drained gutters with filtration substrate represent a solution for cleaning and draining polluted rainwater from asphaltic surfaces: streets and car parking's. Such gutter types are modular and are made of plastic material filled with active filtration substrate. The filter substrate consists of four layers: the absorption layer, the water storage layer, organic matrix for the microorganism retention and a pH adjusting layer. Thus, some of the pollutants (heavy metals) are subjected to physico-chemical processes and others (nickel, lead, cadmium, copper, zinc, etc.) are retained by sorption or precipitation. The substrate has both a pollutants decomposition high capacity and a high water retention capacity.



**Figure 5.** Gutters with filtration substrate. Installation scheme and cross-sections (source: <http://www.funkegruppe.de>)

The pollutants decomposition is very effective, especially at high atmospheric temperatures when sufficient moisture for the filter layer is ensured and the water retention is provided by the hidroabsorbant substrate high volume [5].

At car parking limit and especially of high traffic streets one, the pollutants concentration is more substantial. When there are no adequate drainage systems, there are affected by pollutants also the portions of areas that adjoins the streets and car parking's.

Figure 5 shows the principle by which pollutant substances carried by rain-water are treated before they reaching the soil and then the aquifer.



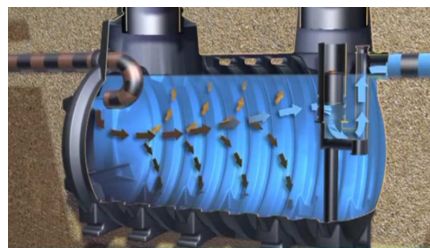
The filter substrate utilization period depending on the load classes with pollutant substances under an average daily traffic conditions is of 20 years at a light load, 18 years for medium load and 15 years at high load [5].

Although the wastewater discharging conditions into the urban sewage systems are governed by regulations and decisions, [16], [17], [18], [19], however there are still many such locations in which any collection, drainage and treatment systems of water polluted with hydrocarbons and other pollutants from road vehicles, are absent.

The hydrocarbons separators are used to prevent leaking in soil and water of petroleum compounds from gasoline, diesel, lubricants, oils and other substances. These systems use the principles of gravitation and coalescence filter by separating the light liquids and sludge from water, but they do not remove water-soluble substances and stable emulsions because these require chemical treatment (Fig. 6).



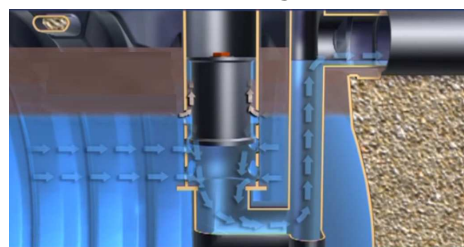
a) Polluted rainwater entrance into the separator



b) The gravitational principle highlighting



c) Sludge layer deposit



d) Oil/fuel exhaust

**Figure 6.** The hydrocarbons separators operation principle

(Source: <http://www.kessel.ro>)

The waste water polluted by petroleum compounds are directed inside the separator through a stilling pipe which enables them to flow slowly and to uniformly distribute into the separation system (Fig. 6). If the flow speed of the wastewaters is high, the separation process inside the system will be disturbed. Due to the gravitational force (Fig. 6b), the separation process between heavy



compounds (sludge) (Fig. 6c) and light compounds (oil, gasoline, diesel) (Fig.6.d), from wastewaters occurs. It is mandatory that hydrocarbons separators to be installed in car parking, car servicing, industrial areas, car washes, service stations, and other places in which petroleum compounds are used. For a higher efficiency, these contaminated water depollution systems are installed in areas with pedestrian traffic or uncirculated areas near the contaminated water source [20].

#### 4. Conclusions

Transportation and industrial activities are known as generating source of oils and hydrocarbons large amounts which float on water surface. The wastewater from these activities, especially those resulting from vehicle washing, cleaning, repairing and replacement of oiled components, but also of rainwater contaminated with petroleum products from car parking's, roads, etc., require both separation and treatment for the environment protection.

Although the nature has its own treatment mechanisms, in order to avoid negative effects on ecosystems and water quality some measures are necessary to be taken for limiting the uncontrolled discharge of pollutants washed by rainwater from rough surfaces.

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