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MANAGING THE QUALITY OF STORMWATERS / UPRAVLJANJE KVALITETOM ATMOSFERSKIH VODA

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Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders

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INTRODUCTION /UVOD

The urban planning affects natural hydrological cycle obviously as increasing surface runoff, decreasing of infiltration and evaporing transpiration. The increasing of runoff includes higher probability of flooding of urban areas primarily. Urban planning also affects decreasing of water underground supplies as well as quality of all waters, both ground and underground.

Uticaj urbanizacije na prirodni hidrološki ciklus se ogleda u povećanju površinskog oticaja, smanjenja infiltracije i evapotranspiracije. Povećanje oticaja podrazumjeva i veću vjerovatnoću plavljenja prije svega urbanih prostora. Urbanizacija takođe utiče na smanjenje zaliha vode u podzemlju i na kvalitet svih voda, površinskih i podzemnih

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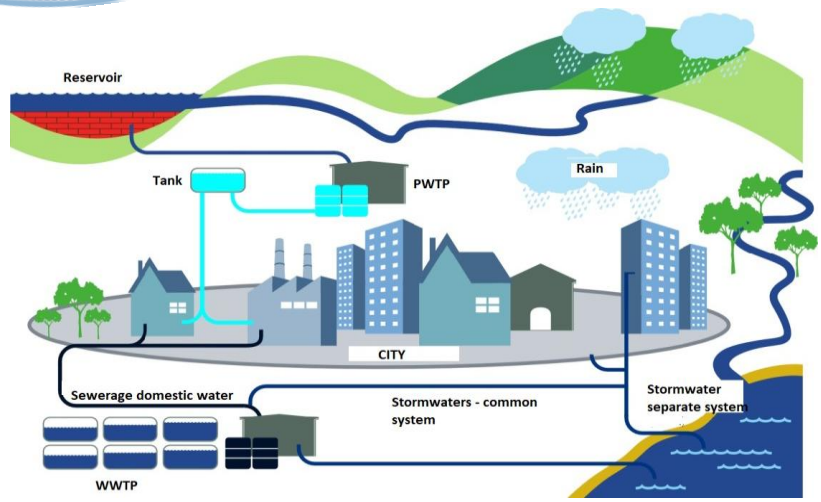

Figure 1. Typical urban water cycle / tipični ciklus kruženja urbanih voda

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Products of burning, substances made out of warned out vehicle parts, industrial pollution products etc. are precipitates from the atmosphere on urban areas. During rains, these substances are separated from the ground and transported by runoff, which makes runoff quality endangered comparing to its natural condition. Preserving the environment must contain treating of stormwater runoff, including all technical measures which contribute to it, such as building of cargo overflows in mixed sewage system etc. **The ultimate goal of managing the stormwater runoff quality is decreasing of negative effects of human activities.**

Na urbanim površinama se iz atmosfere talože produkti sagorjevanja, materije nastale habanjem djelova vozila, produkti industrijskog zagađenja i dr. Tokom padavina ove materije bivaju odvojene od podloge i transportovane oticajem, pri čemu je kvalitet oticaja narušen u odnosu na prirodno stanje. Obezbjeđenje zaštite životne sredine mora sadržati tretiranje kišnog oticaja, uključujući sve tehničke mjere koje tome doprinose kao što je npr. izgradnja rasteretnih preliva u mješovitom kanalizacionom sistemu i sl. **Krajnji cilj upravljanja kvalitetom kišnog oticaja je prije svega smanjenje negativnih uticaja od ljudskih aktivnosti.**

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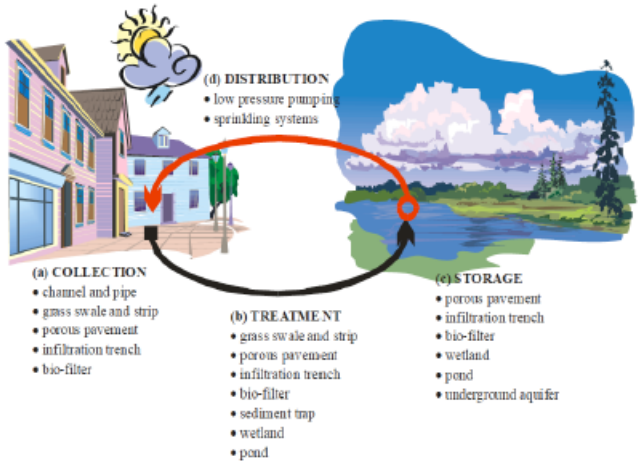

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Difficulties in satisfying needs regarding requiring quality of a stormwater runoff before its discharging originate in accidental features of stormwater runoff's appearing, large changes in flows, different pollutions that can appear and big variations of pollution concentration, both in basin space and for a certain period of time.

Teškoće u uspostavljanju zahtjeva u pogledu zahtjevanog kvaliteta kišnog oticaja prije ispuštanja su uzrokovane slučajnim karakterom pojave kišnog oticaja, velikim promjenama proticaja, različitim zagadenjima koja se mogu javiti i velikim varijacijama koncentracija zagadenja, kako prostorno po slivu, tako i po vremenu.

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Various basin surfaces act differnetly regarding the atmospheric runoff from them. With impermeable surfaces, the first runoff (first flush) releases the most pollution, because the rain washes the impurities on impermeable surface first (highway, pedestrian zones, roofs, etc). Most permeable surfaces (lawns, soil) do not show signs of initail highly polluted runoff, yet the quantity of pollution primarily depends on intensity and duration of rain.

Različite površine slivova različito se ponašaju kada je u pitanju uticaj atmosferskog oticaja sa njih. Kod nepropusnih površina prvi talas oticaja nosi najviše zagađenja, jer voda u početku spira nečistoće akumulirane na nepropusnoj površini (kolovoz, trotoari, krovovi, i sl.) Kod većine propusnih površina (travnjaci, zemljište) ne postoji izrazita pojava početnog vrlo zagađenog oticaja, već količina zagađenja prvenstveno zavisi od intenziteta i trajanja kiše

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KOLIČINE

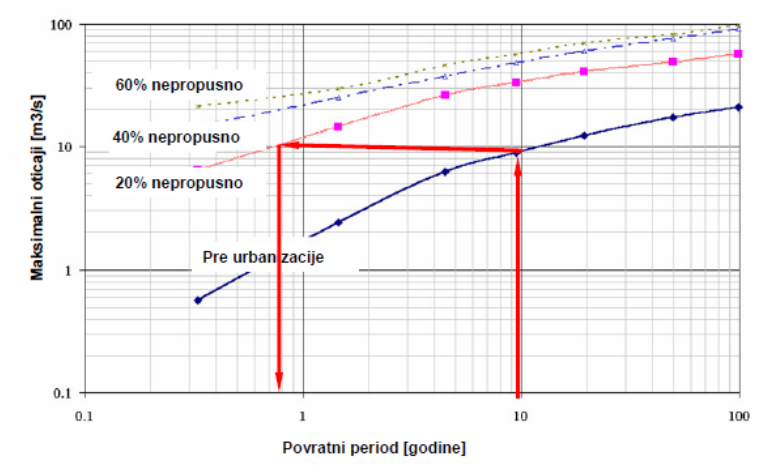

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Table 1.: Typical annual pollution loads from areas of various purposes, expressed in kg/ha annually (Hvitved-Jacobsen and co, 2010)

Tabela 1. Tipična godišnja opterećenja zagađenjem od oticaja sa jednice površine različitih namjena, izražena u kg/ha.god (Hvitved-Jacobsen i sar. 2010)

Parameters	Area type – Land use						
	Commercial	Habitation			Industry	Roads	Parking lots
		High density	Medium density	Low density			
TSS	1100	450	270	10	550	1000	450
TP	1,7	1,1	0,4	0,05	1,5	1,0	0,8
TKN	7,5	4,7	2,8	0,3	3,7	8,9	5,7
BOD_5	70	30	15	1	-	-	53
COD	470	190	60	10	230	-	300
Pb	3,0	0,9	0,06	0,01	0,2	5,0	0,9
Zn	2,3	0,8	0,1	0,05	0,4	2,3	0,9
Cu	0,4	0,03	0,03	0,01	0,1	0,4	0,07

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Researches of stormwater runoff quality from urban and suburban basins performed so far indicate the presence of following pollutions most frequently:

- Ogranic pollutions;
- Suspended substances;
- Heavy metal;
- Oils and lubricants;
- Nitrogen and phosphorus compounds.

Dosadašnja istraživanja kvaliteta kišnog oticaja sa urbanih i suburbanih slivova ukazuju na najčešće prisustvo sledećih zagadenja :

- organska zagadenja;
- suspendovane:;
- teški metali;
- ulja i masti;
- jedninjenja azota i fosfora.

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Table : Degree of concentration of certain pollution parameters in stormwater runoff from urban basins according to results of examinations in USA (Metcalf and Eddy, 2002).

Tabela . Opsezi koncentracija pojedinih parametara zagadenja u kišnom oticaju sa urbanih slivova prema rezultatima ispitivanja u SAD (Metcalf and Eddy, 2002)

Parameter	Concentration
Total of suspended substances (mg/l)	67-101
BOD5 (mg/l)	8-10
HOD (mg/l)	40-73
Coliform bacteria (number/100 ml)	10000-100000
Total Kjeldahl nitrogen (mgN/l)	0,43-1,00
Nitrates (mgN/l)	0,48-0,91
Total phosphorus (mgP/l)	0,7-1,66
Copper (mg/l)	0,027-0,033
Lead (mg/l)	0,030-0,144
Zink (mg/l)	0,135-0,226

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PROTECTION STRATEGY / STRATEGIJA ZAŠTITE

If protecting the surface and underground waters from stormwaters' pollutions is the aim, the very first thing which needs to be done is establishing their exact origin. The next required step is to estimate the type and the range of other possible sudden basin pollutions. For each of possible pollution, it is required to determine the possibility of its appearing and make the estimation of its possible influence. With basis in such analyses, it is possible to estimate the importance of certain pollution type, in other words, the total of probability of basin pollution appearing

Ako se žele štititi površinske i podzemne vode od zagađenja atmosferskim vodama najpre se mora utvrditi njihovo tačno porijeklo. Sledeći korak koji se mora procijeniti su vrste i obim ostalih mogućih iznenadnih zagađenja u slivu. Za svako od mogućih zagađenja treba utvrditi vjerovatnoću njegove pojave i procjenu mogućeg uticaja. Na osnovu tako napravljene analize može se procijeniti važnost pojedine vrste zagađenja, odnosno ukupna vjerovatnoća pojave zagađenja u slivu.

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STOMWATERS' TREATMENT / TRETMAN ATMOSFERSKIH VODA

The control of stormwater runoff quality includes fllowing:

1. Infiltration – water percolation through the
2. Retension – water retension
3. Controlled way of transferring water from one basin into it, or, in other words, from one place to another by ground channels, collectors or trenches.
4. Using of stormwaterfor watering, streets washing or other purposes, depending on local conditions.

Kontrola količina otekle kišne vode obuhvata sledeće :

1. Infiltracija - procjeđivanje vode kroz tlo
2. Retenziranje - zadržavanje vode
3. Prevođenje vode na kontrolisani način iz sliva u sliv, odnosno sa sa jednog na drugo mjesto površinskim kanalima, kolektorima ili rovovima.
4. Korišćenje atsmosferskih voda za navodnjavanje, pranje ulica ili u druge svrhe, u zavisnosti od lokalnih uslova..

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Chart . Recommended treatment techniques considering the type of pollution

Tabela . Preporučene tehnike prečišćavanja obzirom na vrstu zagađenja

POLLUTION	TREATMENT MECHANISM
Nutrients, phospohorus, nitrogen	Settling, biodegradation, precipitation, denitrification
Sediments, suspended substances	Settling, filtration
Hydrocarbons	Biodegradation, photolysis, filtration, absorption
Metals, lead, copper, zink, quicksilver, cadmium, chrome, aluminium	Settling, absorption, filtration, percipitation,
Pesticides	Biodegradation, absorption, evaporation
Chlorides	Prevention
Ciyanides	Evaporation, photolysis
Solid waste	Physical removal - regular maintenance
Organic substances	Settling, filtration, biodegradation

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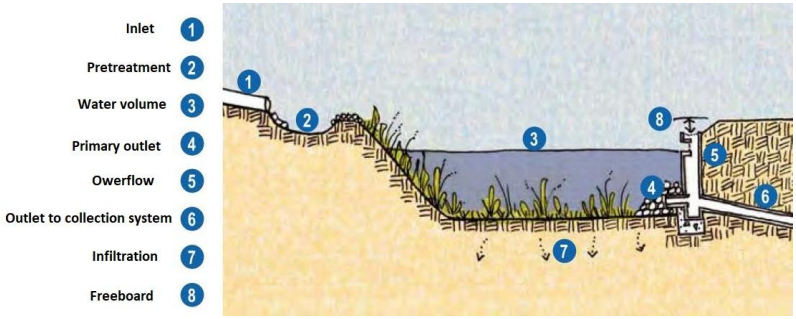
1. **Percipitation** is one of the primarily ways for cleansing the rain waters. The most of the pollution in runoff is connected to suspended substances, so their percipitation can significantly decrease the quantity of pollutants in the runoff.

1. **Taloženje** je jedan od primarnih načina prečišćavanja kišnih voda. Najveći dio zagađenja u oticaju je vezan za suspendovane čestice, te se njihovim taloženjem značajno može smanjiti količina zagađujućih materija u oticaju.



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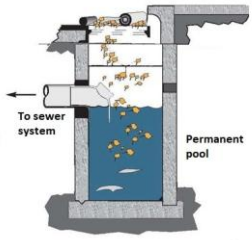
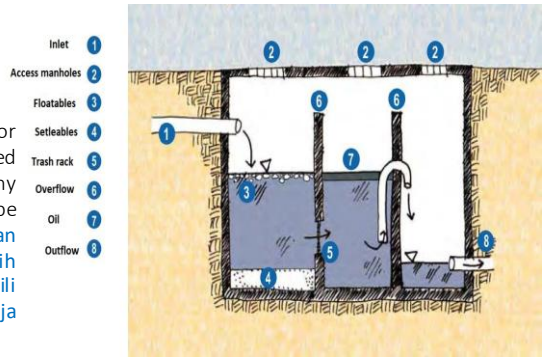


Depositor in atmospheric sewage system shaft – Used on highways, for basins less than 1-2 ha, appropriate for urban areas / Taložnik u oknu atmosferske kanalizacije - koristi se na saobraćajnicama, za manje slivove od 1 – 2 ha , pogodno za urbane sredine

Separator of oils and fats - appropriate for treatment of heavily polluted stormwater(pollutats from highways or any other area where petroleum products can be spilled on). / Separator ulja i masti, - pogodan za tretman jako opterećenih atmosferskih voda zagađenjem sa saobraćajnih površina ili prostora sa kojih može doći do izlivanja naftnih derivata.



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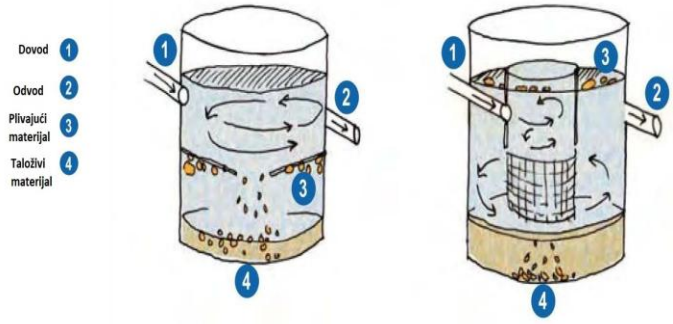

Hydrodynamic separators / Šema funkcionisanja hidrodinamičkog separatora

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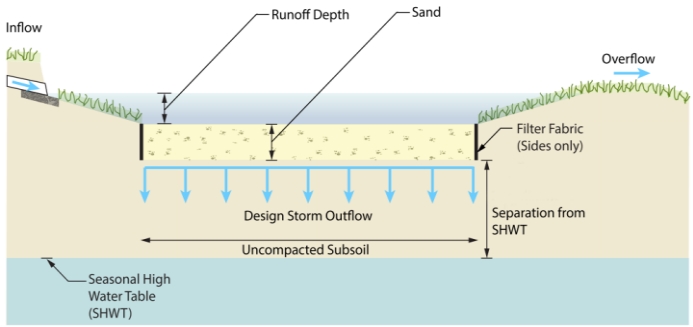
Filtration and biofiltration through the soil, generator or artificial substances (geotextile) removes polluted substances by filtration. Also, biochemical processes can take place in filtering material and remove organic substances and nutrients. / **Filtracija i biofiltracija** kroz zemljište, agregat ili vještačke materijale (geotekstil) uklanja zagađene materije filtracijom i u filterskom materijalu se mogu odigrati biohemijski procesi i ukloniti organske materije i nutrijenti



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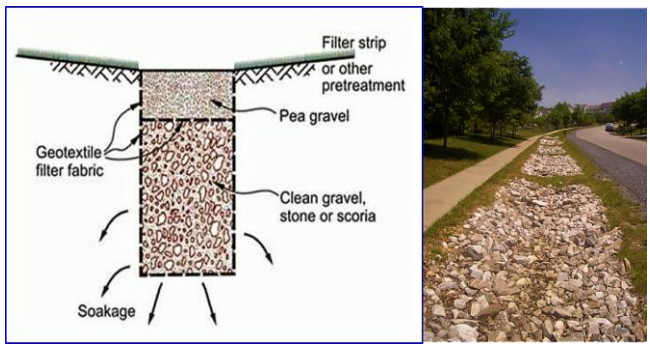

Infiltration through sand and gravel – appropriate for medium permeable areas, removes smaller substances and some dissolved pollutants. It is applicable for urban areas, appropriate for water inflows from the roof tops for areas smaller than 2 ha / inflitracija kroz pjesak i šljunak – pogodno za područja sa umerenom propustljivošću, uklanja sitnije čestice i neke rastvorene zagađivače. Primjenjuje se u gradskim sredinama, pogodno i za za prijem voda sa krovova za površine manje od 2 ha.

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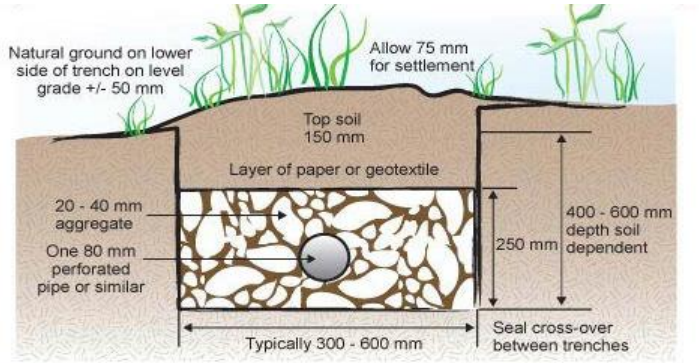
Absorption represents linking the pollution for solid substances surfaces. The polluted waters are running through certain substances, which can become saturated by the time and end the absorption process. There are various mechanisms against absorption / **Absorpcija** predstavlja vezivanje zagađenja za površinu čvrstih čestica. Materijal kroz koji protiče zagađena voda vremenom je zasićen nečistoćom pa može doći do prekida procesa adsorpcije. Postoje različiti mehanizmi sorpcije



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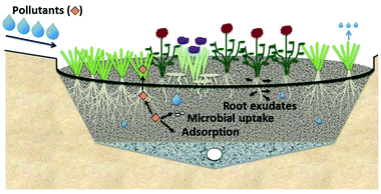
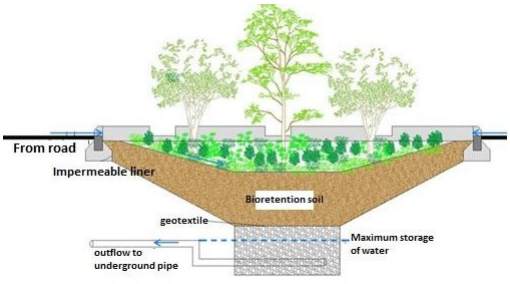
Biodegradation represents a biological process, where microbiological communities form biodegradable organic substances (oils, fats, etc) within ground area and use the oxygen and nutrients from infiltrated water. / Biodegradacija predstavlja biološki proces, gdje se mikrobiološke zajednice formiraju u okviru zemljišne sredine i biodegradabilne organske materije (ulja, masti, i dr.) i koriste kiseonik i nutrijenate iz voda koja se infiltrira.





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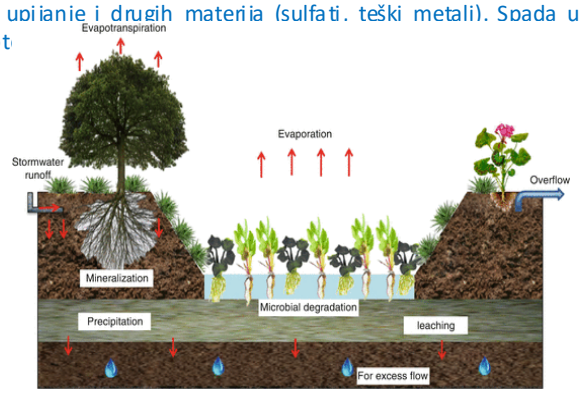
Plants' absorption – plants in lakes and puddles use certain compounds from the water in process of photosynthesis. This way, phosphorus and nitrogen compounds are extracted and built in into biomass, with absorbing of the other substances as well (sulphates, heavy metals). It is classiefied as tertial degree of treatments loaded by stormwaters. / **Upijanje biljaka** - biljke u jezerima i barama koriste određena jedinjenja iz vode u procesu fotosinteze. Ovim putem se izvajaju iz vode jedinjenja fosfora i azota i ugrađuju u biomasu, uz upijanje i drugih materija (sulfati, teški metali). Spada u tercijarni stepen tretmana opt



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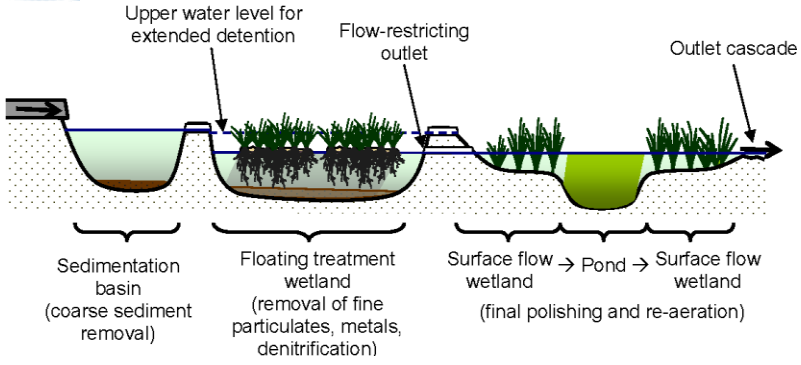

System of artificial swamps which includes multiple phases of processing of stormwaterdischarge (into it). They keep the smaller sediments and nutritients, have a high level of efficiency in preserving different inflow quantities, possible valorization as a new type of habitat of different plants' and animals' species, help retention of flood wave.. / Šema sistema vještačkih močvara koji uključuje više faza obrade ispuštenih atmosferskih voda u nju. Zadržavaju sitnije taloge i hranljive sastojke, imaju visoku efikasnost zadržavanja za različite vrijednosti dotoka, moguća valorizacija kao novi tip staništa raznih biljnih i životinjskih vrsta, pomažu zadržavanje poplavnog talasa.

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Nitrification is the process where amoniac and aluminium ions form nitrates by biochemical oxidation, in presence of certain bacteria / **Nitrifikacija** je proces gdje amonijak i amonijum joni biohemijskom oksidacijom uz prisustvo određenih bakterija formiraju nitrate.

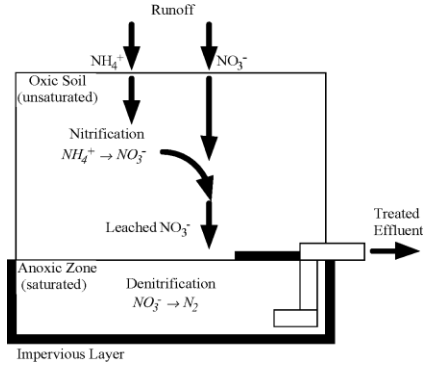

Diagram of Modified Bioretention for Denitrification / Šema modifikovane biodegradacije za process denitrifikacije azota

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What becomes more present worldwide is inovative approach to managing atmspheric waters, which relies on principles of designing that would be as similar to the natural runoff conditions as possible. This approach has the starting point in principle of equal division of atmospheric runoff by its redirecting to decentralized drainage micro-systems, using the techniques which predict water retention in retensions, infiltration into the underground, evaporation, filtration etc. This approach is used to achieve the best and the fastest possible integration of stormwateraround natural enviroment, urban areas and wider.

U svijetu je sve više prisutan, može se reći inovativan pristup upravljanja atmosferskim vodama, koji se oslanja na principe projektovanja koji će biti što bliži prirodnim uslovima oticanja. Ovaj pristup polazi od principa ravnomjerne raspodjele atmosferskog oticaja njegovim usmjeravanjem na decentralizovane mikro sisteme odvodnje, koristeći se tehnikama koje predviđaju zadržavanje vode u retenzijama, infiltraciju u podzemlje, evaporaciju, i filtraciju i drugo. Ovim pristupom se želi postići što bolja i brža integracija atmosferskih voda u okolni prirodni prostor u urbanoj sredini a i šire.

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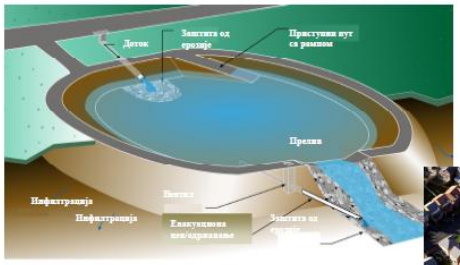
INFILTRACIONI BAZENI
(Infiltration basins)



RETENZIONI BAZENI
(Detention basins)

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JEZERA (PONDS)

KIŠNA POLJA-LAGUNE
(Stromwater wetlands)

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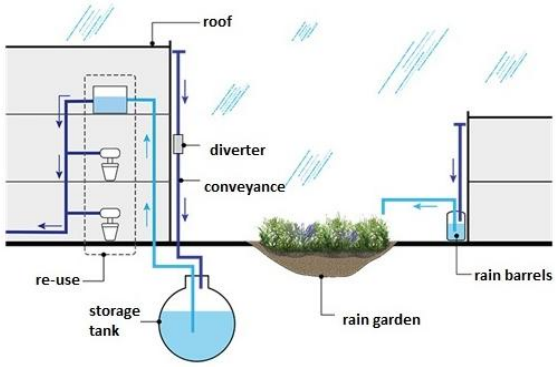

System for collecting rain water from roof tops, cleaned by biofiltration and stores it for watering greenery or gardens, decreases the use of drinking water, but also decreases atmospheric water quantity which is released into sewage system, what makes it suitable for locations where water infiltration is not appropriate. / Sistem za prikupljanje kišnice sa krova , koja se čisti pomoću biofiltracije i skladišti za navodnjavanje zelenila ili vrta, smanjuje upotrebu pijaće vode, smanjuje količine atmosferske vode koje odlaze u sistem kanalizacije, pogodno za za lokacije na kojima infiltracija vode nije pogodna opcija

CONCLUSION / ZAKLJUČCI

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- Quality control of stormwater can be achieved by various methods which solve this problem more or less efficiently.
- The quantity of pollution flushed from stormwater runoff depends on surface features, existing of pollutant (highways, factories etc), as well as numerous hydrological and meteorological factors.
- Large spatial and temporal applicability of every parameter of ground runoff,, represents the issue in establishing simple rules and requirements regarding controlling and pollution decreasing appearing with atmospheric waters.

- Kontrola kvaliteta atmosferskih voda može da se postigne pomoću različitih metoda koje manje ili više efikasno rešavaju taj problem.
- Količina zagađenja koje se spira sa kišnim oticajem zavisi od karakteristike površina, postojanje zagađivača (saobraćaj, industrija, i dr.) kao i od brojnih hidroloških i meteoroloških faktora.
- Velika prostorna i vremenska promjenljivost svih parametara površinskog oticaja, predstavlja teškoću u uspostavljaju jednostavnih pravila i zahtjeva u pogledu kontrole i smanjenja zagađenja koje se pojavljuje sa atmosferskim vodama.