Constructed wetlands

OUTLINE

- WHAT ARE CONSTRUCTED WETLANDS (CW)
- TYPES OF CWS
- FUNCTIONING OF CWS
- BUILDING OF CWS
- VEGETATION
- ADVANTAGES X DISADVANTAGES
- EXAMPLES

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- examples


Struhaře, CR, 6 EO
Jan Vymazal

SLAVOŠOVICE, CR, 150 EO

WHAT ARE CONSTRUCTED WETLANDS?

- SYSTEMS CONSTRUCTED BY MEN
- BIOTECHNOLOGY
- USED FOR (WASTE)WATER TREATMENT
- USING NATURAL PROCESSES
- ALTERNATIVE TO CONVENTIONAL WASTEWATER (SEWAGE) TREATMENT PLANTS

What are CWs used for?

- Treating of polluted water
  - Landfill leachate
  - Mine leachate
  - Farmyard runoff
  - Higway runoff
  - Industrial wastewater (e. g.paper mill, food processing factories etc.)
  - Municipal (domestic) wastewater (domestic sewage effluent)
  - surface water from rivers, lakes

History

- Natural wetlands used for wastewater treatment in middle ages (unintentionally)
- First experiments with constructed wetlands in 50th, 20th century, Germany
- the first functioning constructed wetland built in Othfresen, Germany, in 1974
- plastic-lined bed filled with soil and planted with emergent macrophytes
- low hydraulic conductivity of soil – soil replaced by gravel

CURRENT SITUATION IN EUROPE

Country	Number of CWs
Germany	50 000
Austria	1400
Great Britain	800
Denmark	600
Italy	400
Czech Republic, Polland, France, Belgium, Portugese	150

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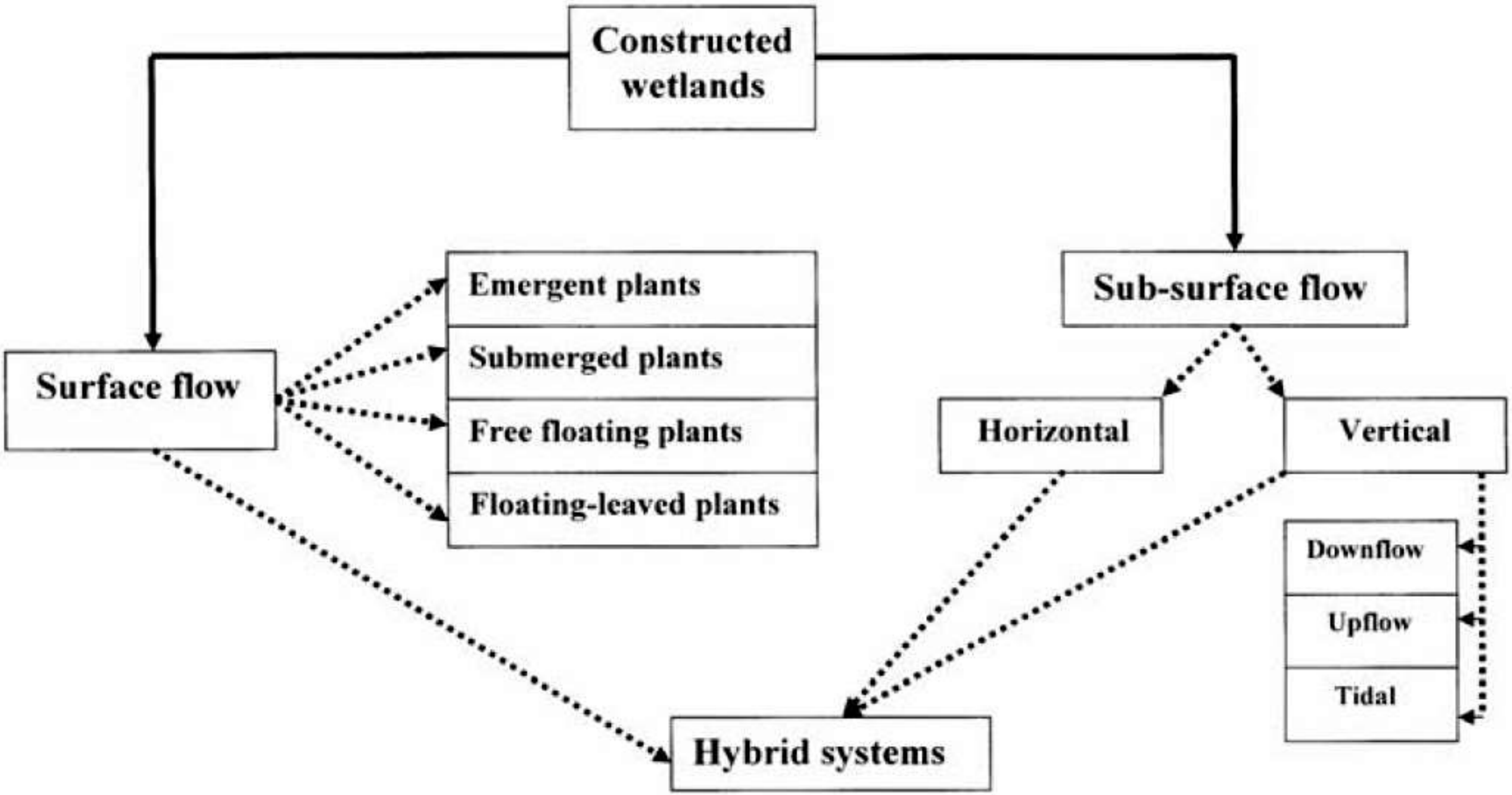
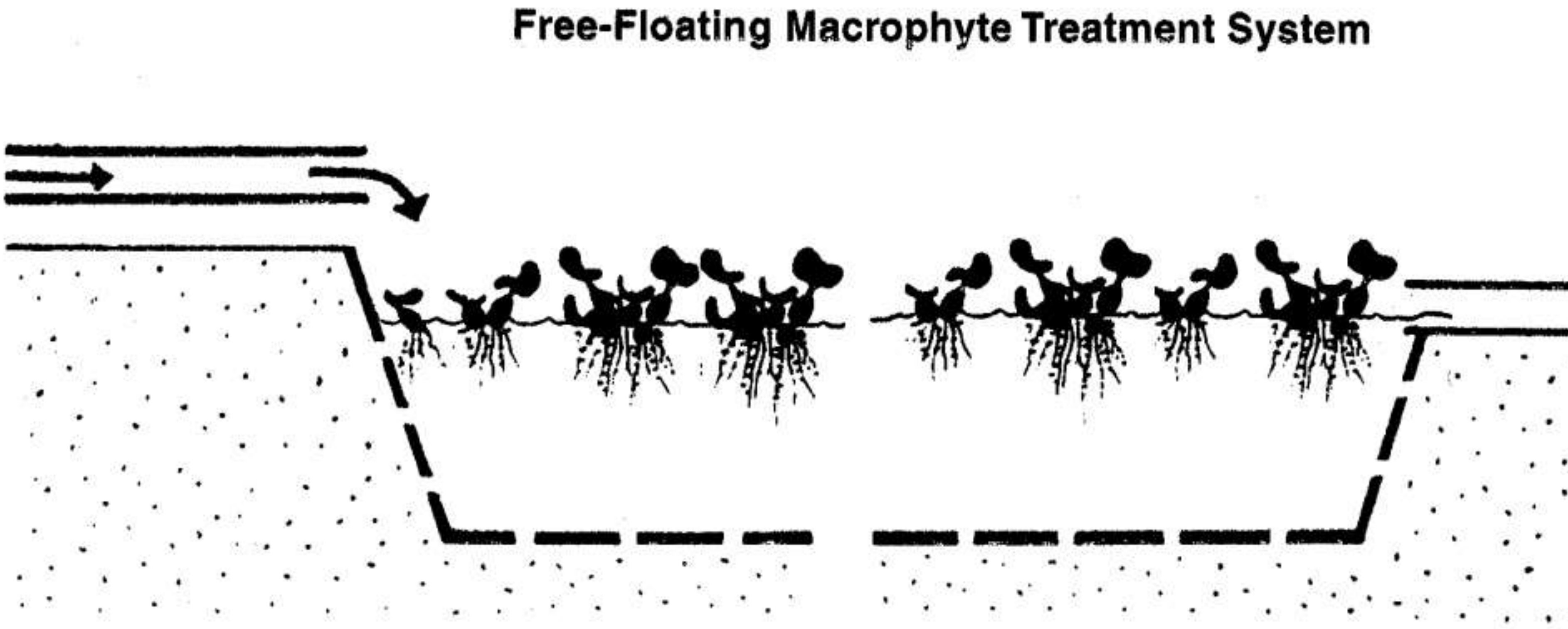
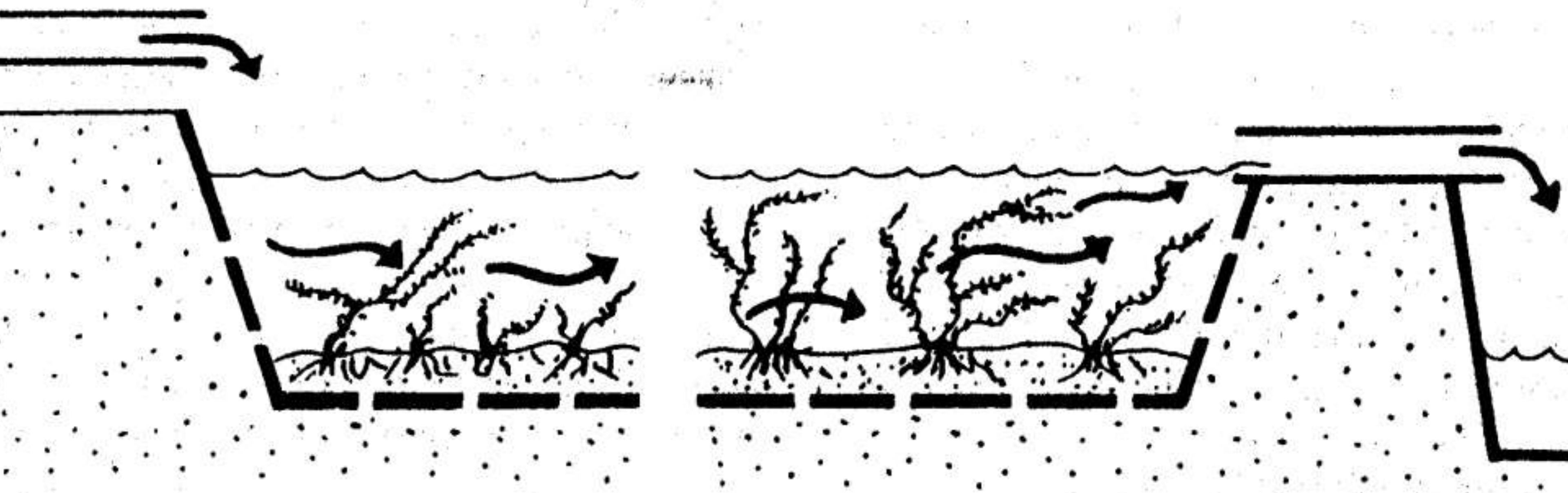
TYPES OF CW


Constructed wetlands
Surface flow
Sub-surface flow
Emergent plants
Submerged plants
Free floating plants
Floating-leaved plants
Horizontal
Vertical
Downflow
Upflow
Tidal
Hybrid systems

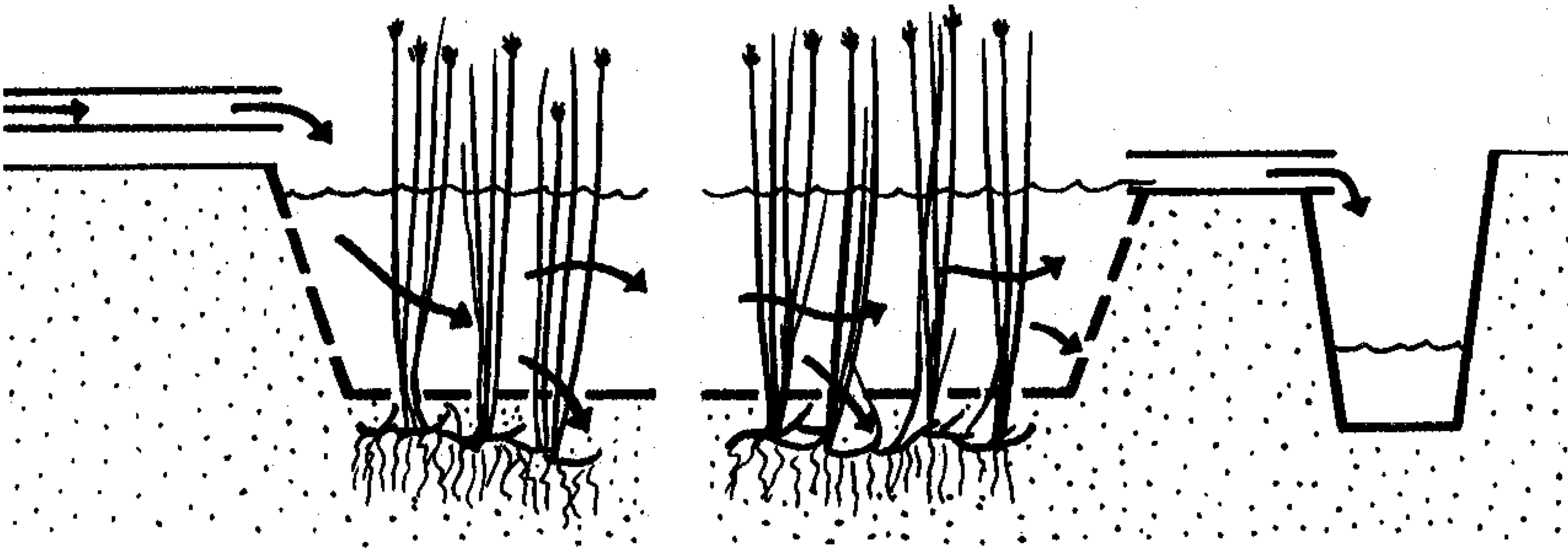


- Eichhornia crassipes (water hyacinth)
- subtropics and tropics
- duckweed (e.g. Lemna)

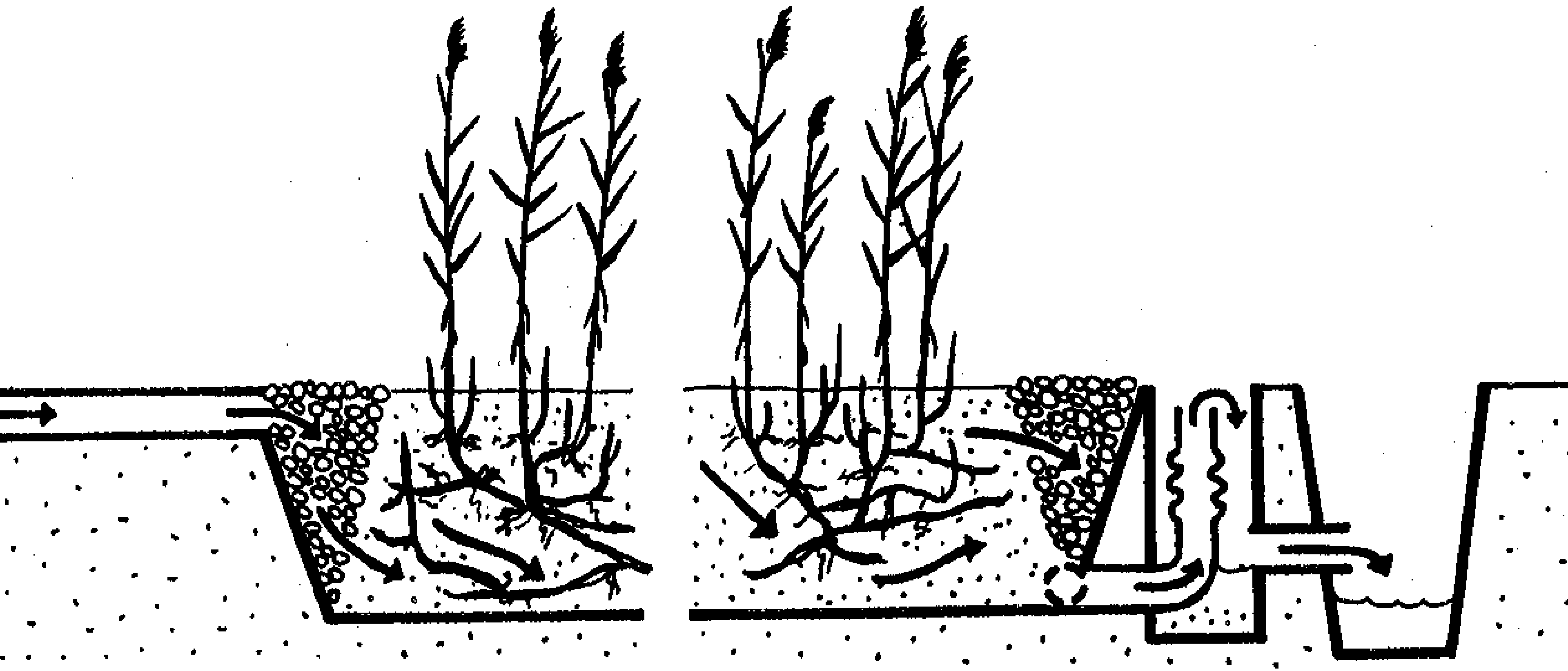
Submerged Macrophyte Treatment System



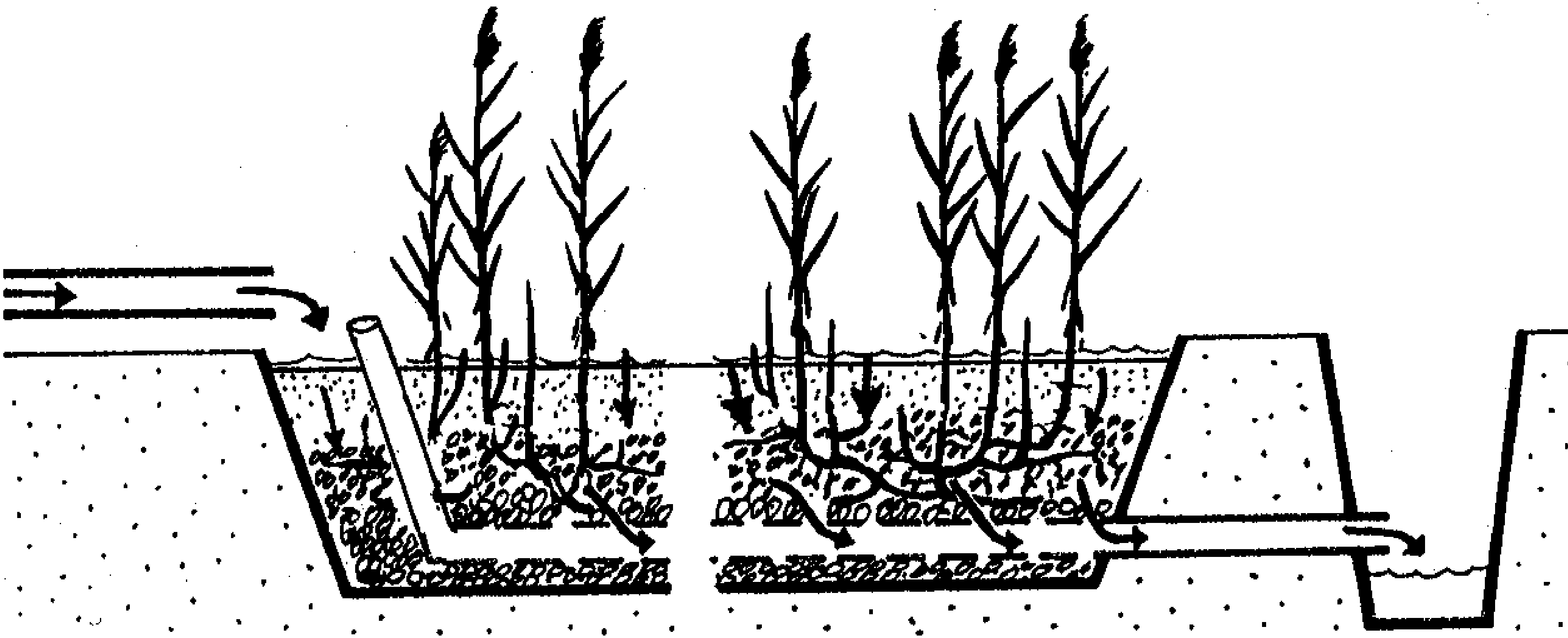
(a) Emergent macrophyte treatment system with surface flow



(b) Emergent macrophyte treatment system with horizontal subsurface flow



(c) Emergent macrophyte treatment system with vertical subsurface flow (percolation)



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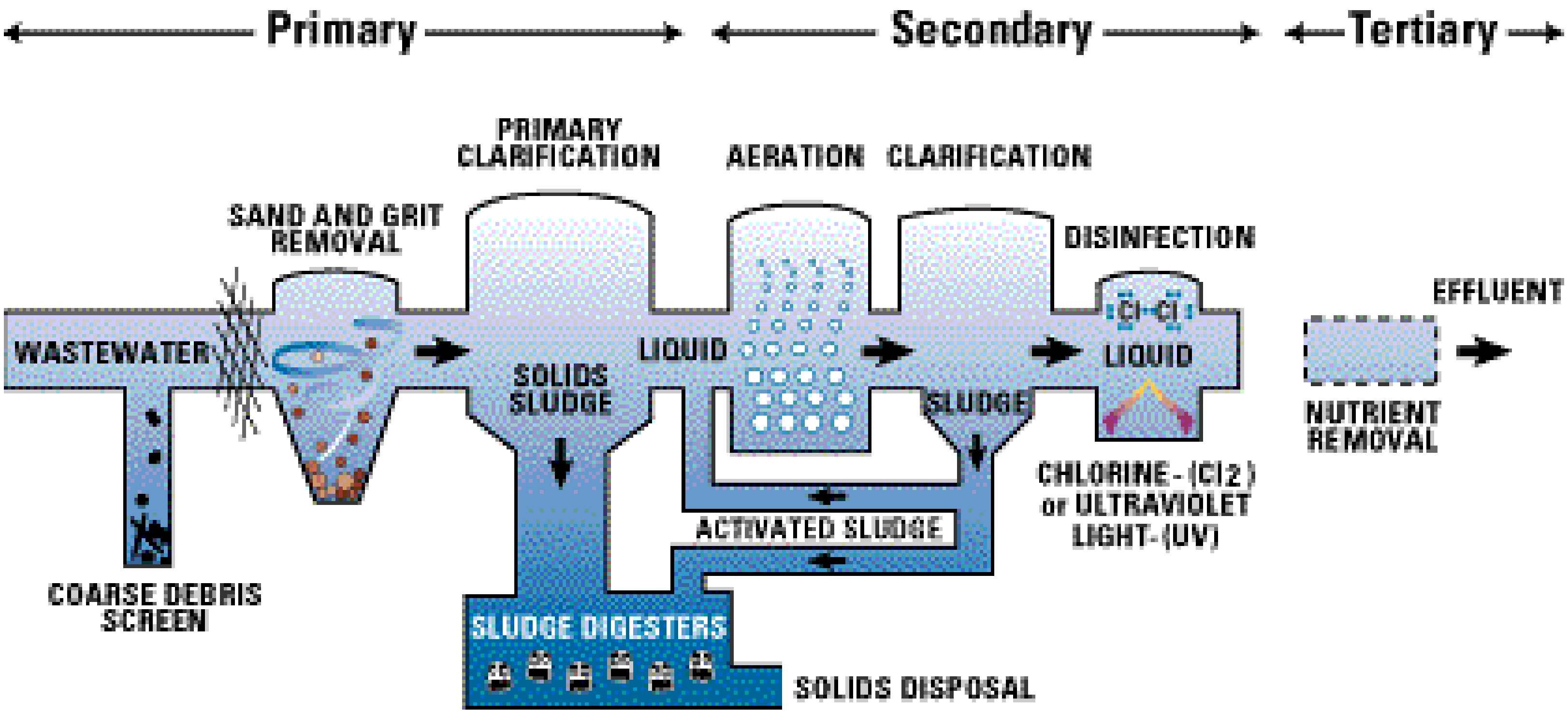
WASTEWATER TREATMENT



Treatment processes

1. settling of suspended particulate matter
2. filtration and chemical precipitation
3. chemical transformation
4. adsorption and ion exchange on the surfaces of plants, substrate, sediment, and litter
5. breakdown and transformation of pollutants by microorganisms and plants
6. uptake and transformation of nutrients by microorganisms and plants
7. predation and natural die-off of pathogens.

IMPORTANT PARAMETERS

- PERSON EQUIVALENT = POLLUTION PRODUCED BY ONE AVERAGE PERSON - THE ORGANIC BIODEGRADABLE LOAD HAVING A BIOCHEMICAL OXYGEN DEMAND (BOD5) OF 60G OF OXYGEN PER DAY.
- REMOVAL EFFICIENCY = PERCENTAGE OF POLLUTANT REMOVED IN CW
- TOTAL SUSPENDED SOLIDS (TSS)
- COD = CHEMICAL OXYGEN DEMAND
- BOD = BIOCHEMICAL OXYGEN DEMAND (BOD5)

- TOTAL NITROGEN
- NITRATES
- AMMONIUM
- TOTAL PHOSPOHORUS
- FECAL AND TOTAL COLIFORMING BACTERIA

Efficiencies of pollution removal by SSHF CW (concentrations in mg L^{-1}, efficiency in %.

		concentration		
	n	INFLOW	OUTFLOW	EFFICIENCY
BOD_5	161	156	15.5	85.3
COD	97	332	56	75.1
TSS	106	164	13.1	92.3
P-TOT	60	6.3	3.1	41.6
N-TOT	33	55	28	44.6
NH_4-N	63	29	18.6	33.3
N-org.	19	15.4	3.1	69.1

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HYDROLOGY

- HYDRAULIC RESIDENCE TIME (HRT) .... THE AVERAGE TIME THAT WATER REMAINS IN THE WETLAND, EXPRESSED AS MEAN VOLUME DIVIDED BY MEAN OUTFLOW RATE
- HYDRAULIC LOADING RATE (HLR) .... LOADING OF A WATER VOLUME PER UNIT AREA BASIS. [LOADING = (PARAMETER CONCENTRATION)(WATER VOLUME/AREA)]

WATER BALANCE EQUATION FOR CW

$$S = Q + R + I - O - ET$$

- S = NET CHANGE IN STORAGE
- Q = SURFACE FLOW, INCLUDING WASTEWATER OR STORMWATER INFLOW,
- R = CONTRIBUTION FROM RAINFALL
- I = NET INFILTRATION (INFILTRATION LESS EXFILTRATION)
- O = SURFACE OUTFLOW
- ET= LOSS DUE TO EVAPOTRANSPIRATION.

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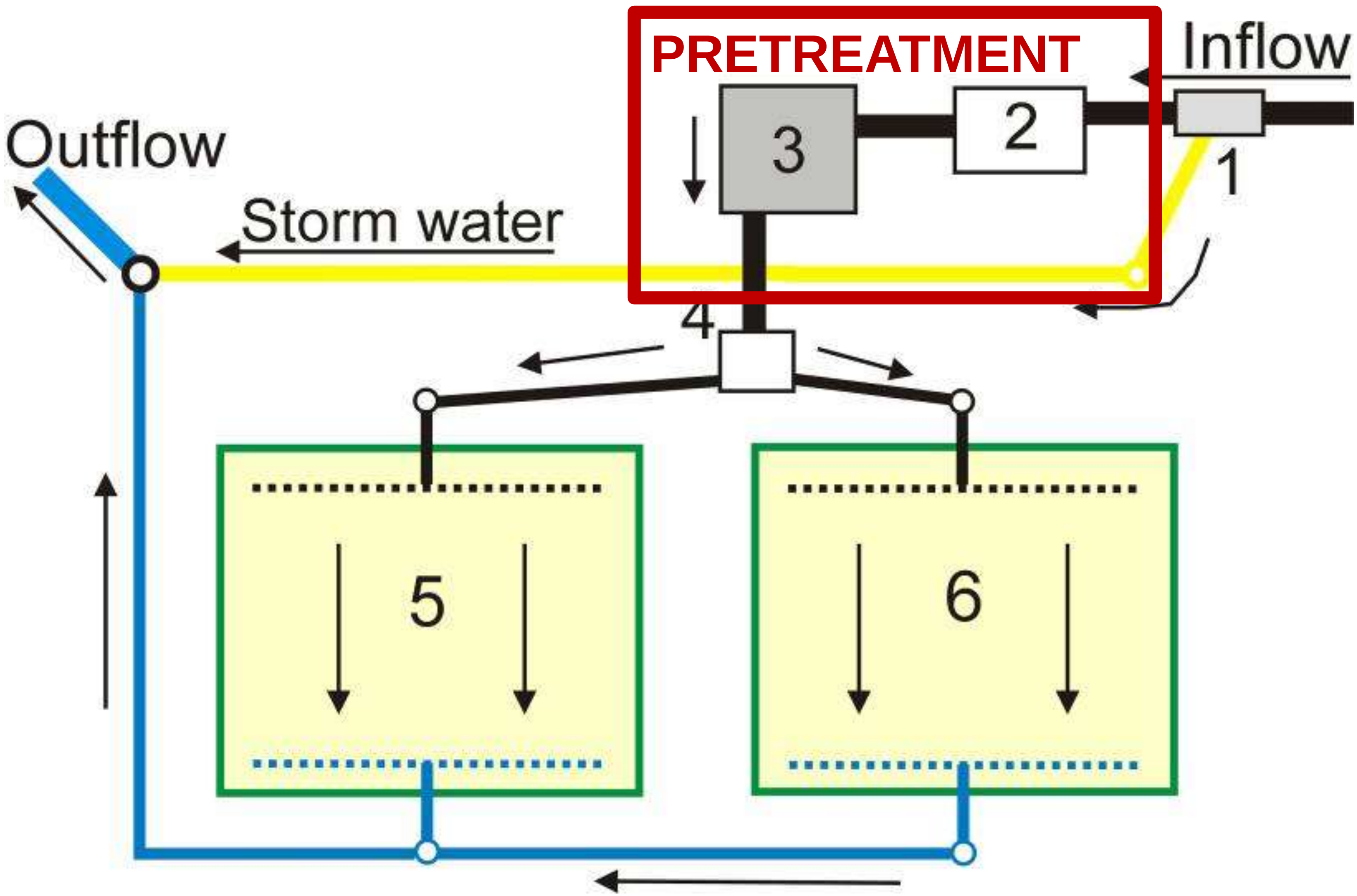
TECHNICAL PARAMETERS OF TREATMENT BEDS (SSF)

- AREA (5 m^2 PER PE)
- DEPTH .... 80 TO 90 CM
- SLOPE 1%



1/ STORM OVERFLOW, 2/ SCREENS, HORIZONTAL SAND TRAP, 3/ IMHOFF SEPTIC TANK, 4/ INFLOW INTO THE BEDS, 5/ AND 6/ BEDS

PRETREATMENT

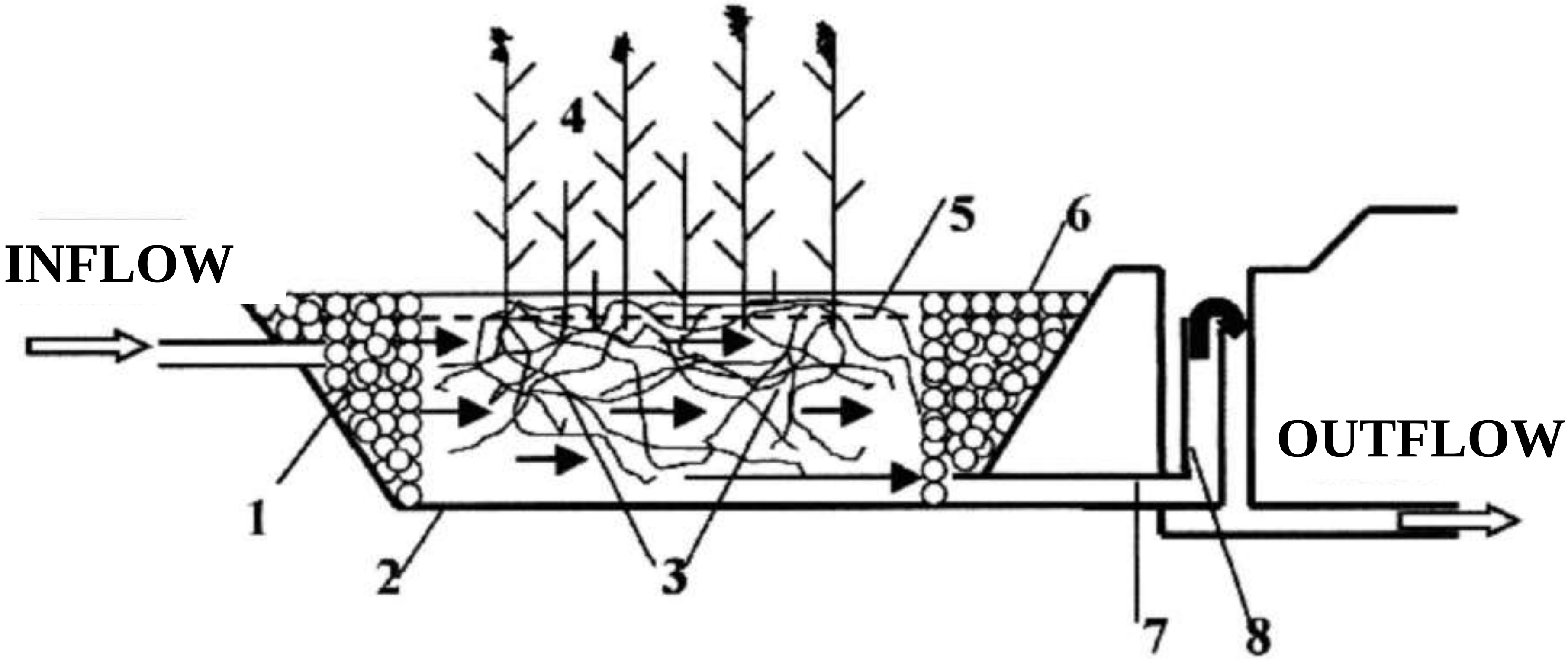
SAND TRAP

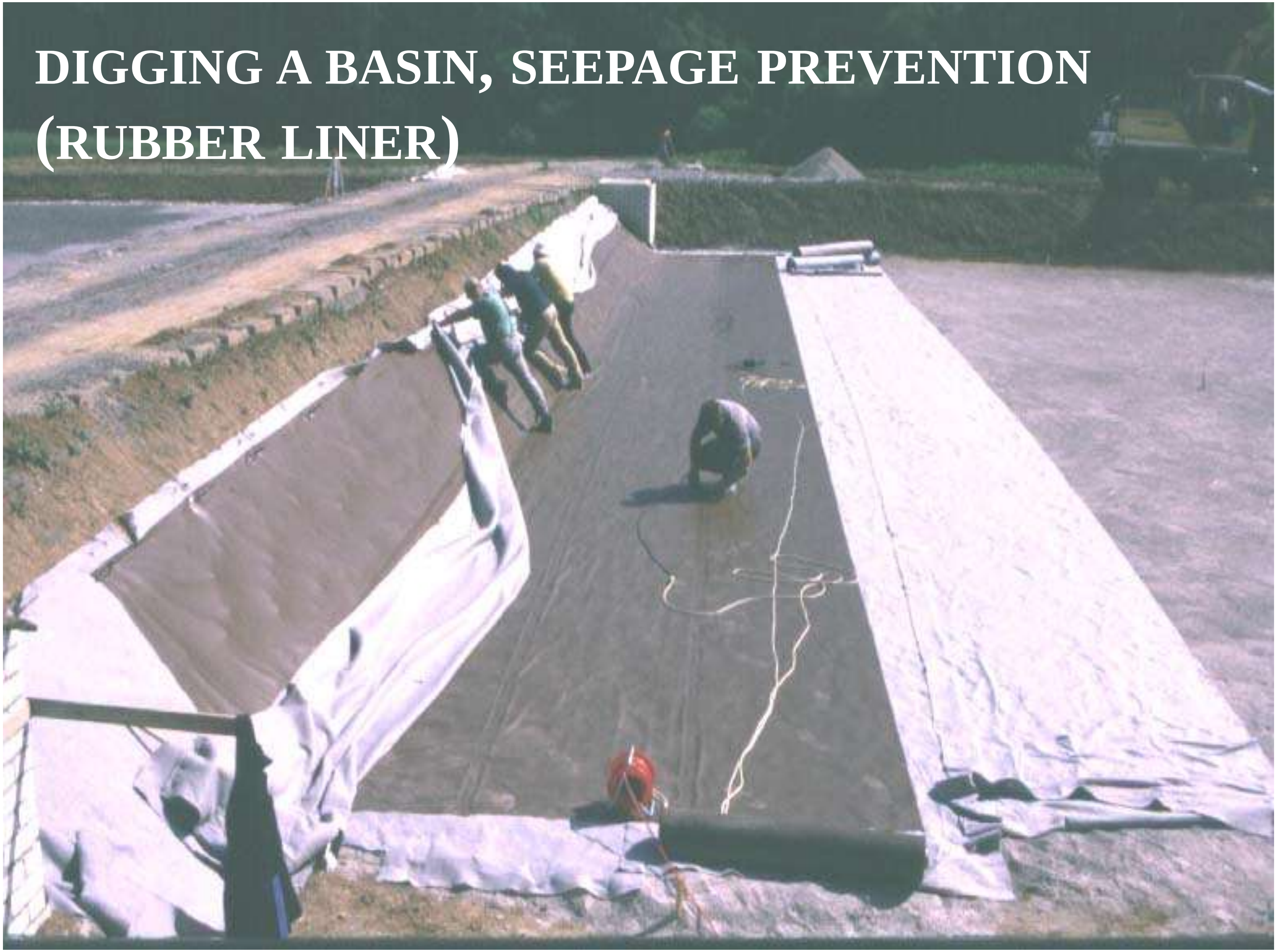
SCREENS

SEPTIC TANK

Treatment bed

CW with horizontal subsurface flow




DIGGING A BASIN, SEEPAGE PREVENTION
(RUBBER LINER)

TREATMENT BED – DISTRIBUTION ZONE

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SUBSTRATE

- SUPPORTS THE WETLAND VEGETATION
- PROVIDES SITES FOR BIOCHEMICAL AND CHEMICAL TRANSFORMATIONS
- PROVIDES SITES FOR STORAGE OF REMOVED POLLUTANTS

- SOIL, SAND, GRAVEL, ORGANIC MATERIALS
- DIFFERENT FOR DISTRIBUTION ZONE AND FOR VEGETATED PART OF REED BED


GRAVEL
32 – 64 mm?
50 – 100 mm
100 – 200 mm
CRUSHED ROCK

Technical parameters of Slavošovice constructed wetland

Number of beds	2
Length of bed	17 m
Width of bed	22 m
Depth of bed	0.8 to 0.9 m
Area of one bed	374 m^2
Number of PE	150
Area per 1 PE	5 m^2
Hydraulic retention time	14 days (18 - 1.5 days)

Outflow

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VEGETATION

- REMOVING PART OF THE NUTRIENTS, BUT USUALLY VERY LOW PORTION
- VENTILATION OF GRAVEL BED (SUBSTRATE) AND ALLOWING OXYGEN TRANSPORTATION INTO THE ROOTS AND THEIR SURROUNDINGS
- SUPPORTING MICROBIAL ACTIVITIES BY INCREASING SURFACES FOR MICROBIAL BIOFILMS AND BY ROOT EXUDATION
- INSOLATION OF BED SURFACE
- EVAPOTRANSPIRATION – PROLONGATION OF HYDRAULIC RETENTION TIME, COOLING EFFECT ON LOCAL CLIMATE AND INCREASING AIR HUMIDITY

PLANT SPECIES USED FOR CW

- TYPHA, PHRAGMITES, PHALARIS, IRIS, GLYCERIA


Jan Vymazal

AUGUST 2001

JANUARY 2002

JUNE 2002

OCTOBER 2002

June 2003

AUGUST 2004

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ADVANTAGES

- THE BEST FOR DISCONTINUOUS WASTEWATER INFLOW AND FOR WASTEWATERS WITH LOW CONCENTRATIONS OF POLLUTANTS
- LOW MAINTANCE COSTS
- NO NEED OF ELECTRICITY (OR VERY LOW)
- NO NEED OF PROFESSIONAL STAFF
- NATURAL SYSTEM – PART OF LANDSCAPE, BIOSTOP FOR PLANTS AND ANIMALS (FROGS, BIRDS, MOSQUITOES ☺)
- COOLING SYSTEM FOR LANDSCAPE, MOISTENING OF AIR IN LOCAL AREA
- CAN SURVIVE FLOODS USUALLY WITHOUT ANY PROBLEMS

DISADVANTAGES

- NEEDS LARGER AREA THAN TRADITIONAL SEWAGE PLANTS
- VARIABLE EFFICIENCY FOR NITROGEN AND PHOSPHORUS REMOVAL
- THE COST CAN BE LITTLE BIT HIGHER THAN FOR TRADITIONAL PLANTS

MAINTENANCE

- CHECKING AND CLEANING OF SCREENS REGULARLY (EACH TWO OR THREE DAYS)
- CLEANING OF SAND TRAP AND OF SEPTIC TANC REGULARLY (TWICE A YEAR)
- CUTTING VEGETATION
- INCREASE THE WATER LEVEL BEFORE WINTER
- WATER SAMPLING TWICE A YEAR AND SENDING IT FOR ANALYSES

Clogging

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Struhaře, 6 EO
Jan Vymazal

Spálené Poříčí 700 (1400 EO)

Mořina 700 EO

Jan Vymazal

Čistá 800 EO

Jan Vymazal

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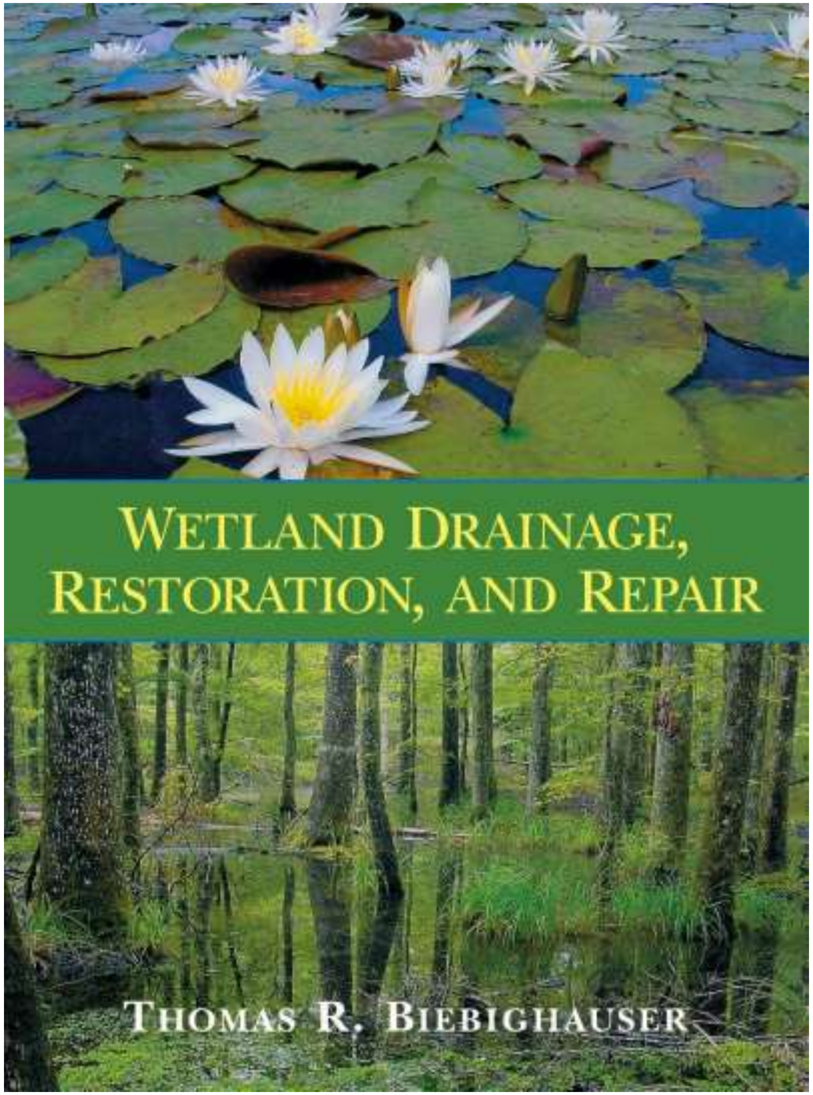

Wetland Drainage, Restoration, and Repair

Thomas R. Biebighauser

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