Dr. Elif Asuman Korkusuz Ülgen

Ph.D. in Biotechnology (METU 2004)
B.Sc. & M.S. in Environmental Eng. (METU 1996 & 1998)

***Part Time Instructor of the Dep. of Enve Eng., METU, Ankara**

***Deputy General Manager of the Optimet Eng. Environmental Technologies Ltd. Co., Ankara (www.optimet.com.tr)**

***Coordinator for Research & Development Projects of OPTİMA Engineering Inc., Ankara (www.optima.tc)**

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asumank@metu.edu.tr

My Academic Background ☺

1984 - 1991: Ankara Anatolian High School, Ankara, Turkey
(education in German language)

1991 - 1996: B.S. in Enve. Eng. of Middle East Technical University
(METU), Ankara, Turkey

1996 - 1998: M.S. in Enve. Eng., METU, Ankara, Turkey.
Thesis: "*Feasibility of A Controlled Wetland in the Mogan-Eymir System*".

1999 - 2004: Ph.D. in Biotechnology of METU, Ankara, Turkey.
Thesis: "*Domestic Wastewater Treatment in Pilot-Scale Constructed Wetlands (CWs) implemented in the Middle East Technical University (METU)*".

2004 - 2005: Post-doc studies for 6 months at Technical University of Crete, Greece.
As a scholar of the Med-Reunet Support Programme
"Manual of Practice on CWs for Manual of Practice on CWs for Wastewater Treatment and Reuse in Mediterranean Countries".

2005-2007: Marie Curie EU Intra European Fellow at SIG-BOKU Vienna.
"***O****ptimization of* ***NU****trient* ***REM****oval in Constructed Wetlands using Special Substrates and Numerical Simulation".*

Experience on Constructed Wetlands for Domestic Wastewater in Turkey...

Dr. Elif Asuman Korkusuz Ülgen

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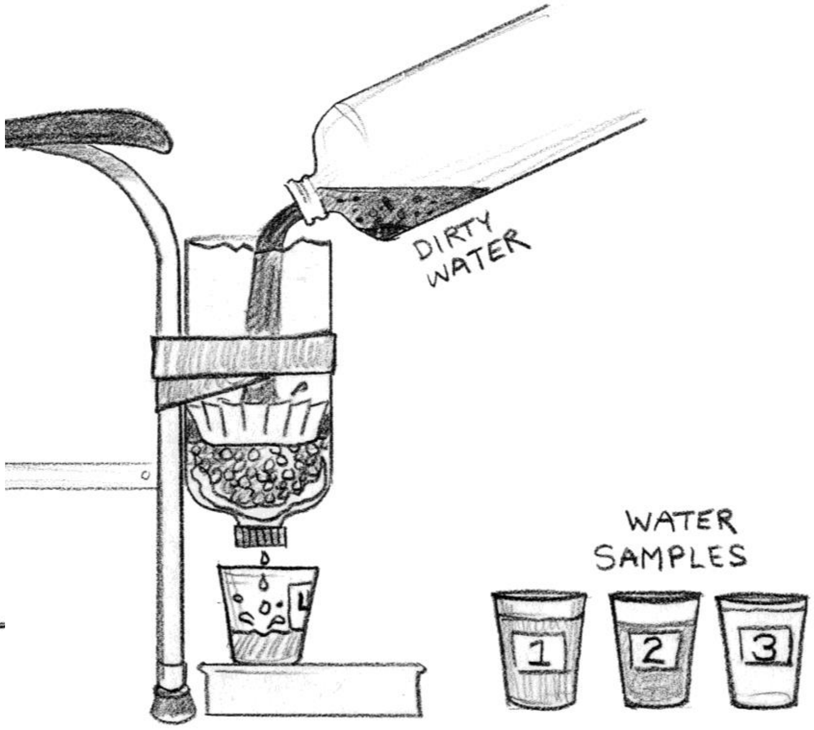
My first Scientific Experiment on Filtration....



Middle East Technical University (METU, Ankara, Turkey)

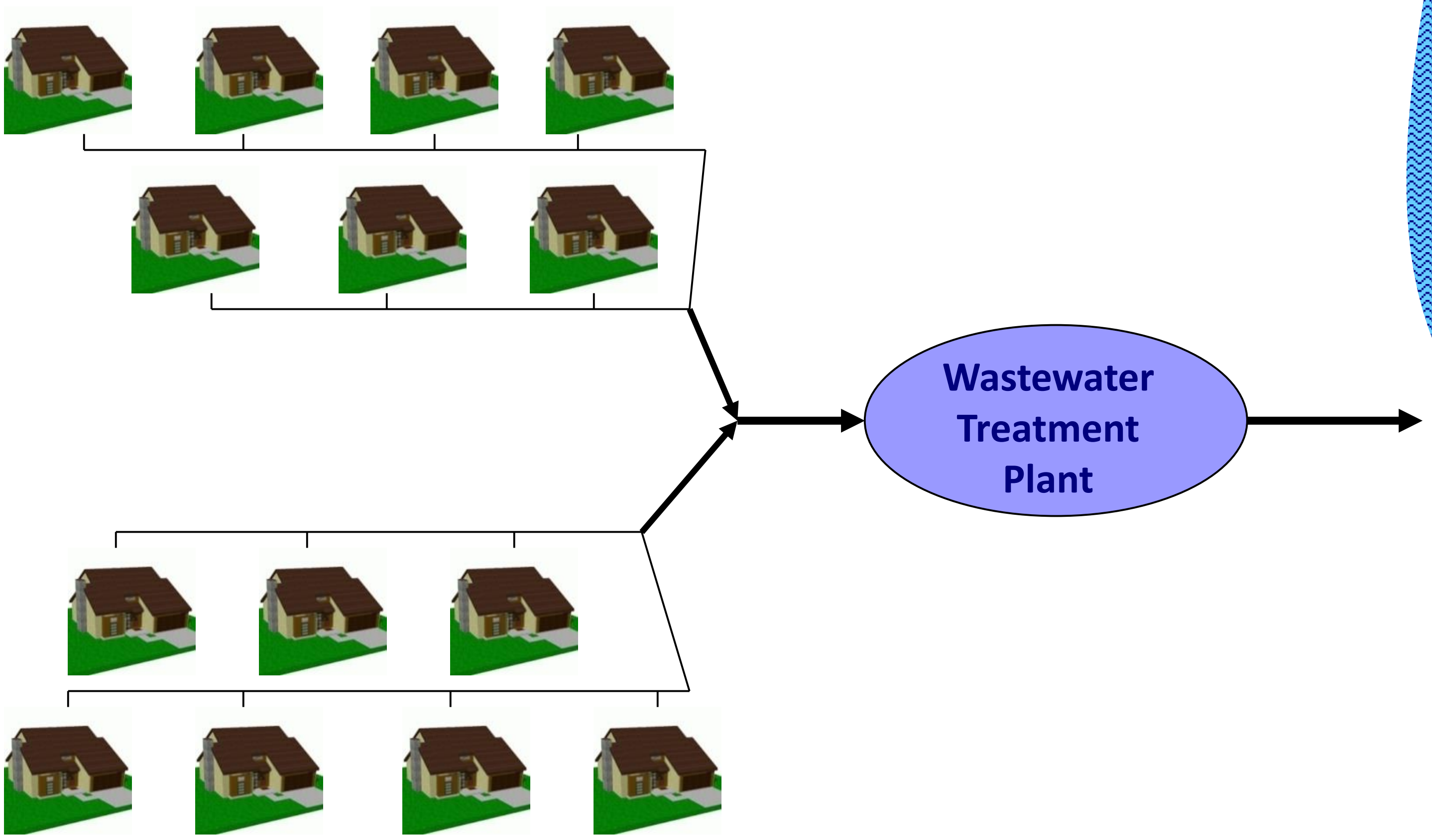
Dep. of Environmental Eng. (1991-1996)

While having my Master degree,
I have attended a graduate course given by the **Dep. of City & Regional Planning, METU**, on “**Ecovillages”**, which has changed my life!!!

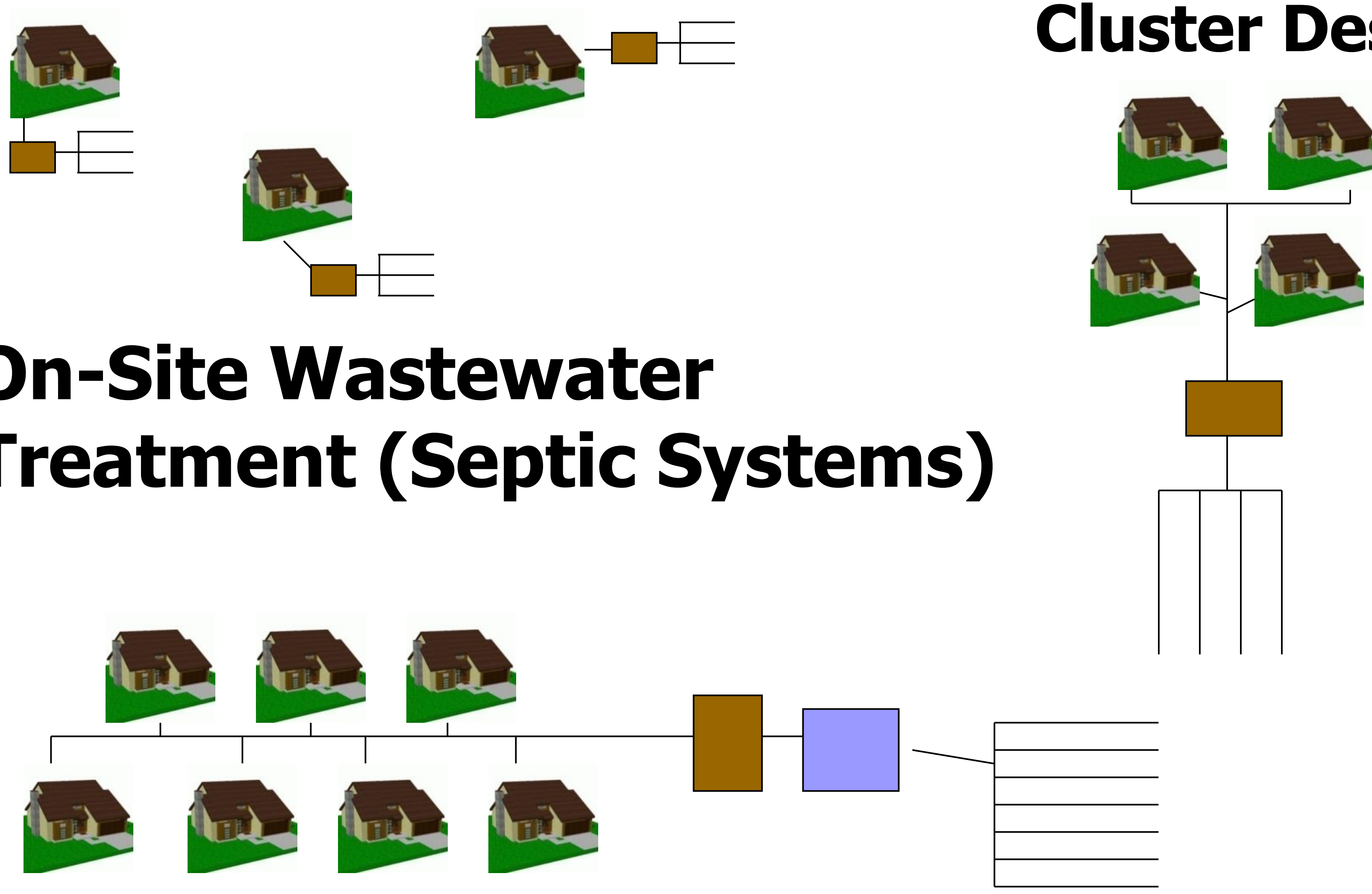
Special Thanks to:
Prof. Dr. Semih Eryıldız

To Centralize or Decentralize? That is the question!

Centralized Treatment System



Decentralized Treatment Systems



Cluster Design

On-Site Wastewater Treatment (Septic Systems)

Large Community Systems

In Europe, for the small sized agglomerations (population<2000 PE), the Council Directive "**Urban Wastewater Treatment**" [91/271/EEC] and «**the Water Framework Directive**» [2000/60/EEC] set a goal to achieve a "**good ecological status**" of European water by the year 2015.

However, for **small communities (<2000 PE)**, several researches have suggested that **Centralized Treatment Systems are unsustainable** from social, environmental, and financial point of view [UNEP, 2006].

Therefore, for the small agglomerations, **Decentralized Management and Application of Natural & Alternative Extensive Treatment Systems** is receiving increased attention from wastewater professionals and researchers.

HENCE, for these small communities, implementation of:

EFFICIENT,

COST EFFECTIVE,

SIMPLE,

PRACTICAL,

RELIABLE

& ENVIRONMENTALLY FRIENDLY

"Natural and Alternative Treatment Systems"

can be considered.

As being one of the **DECENTRALIZED TREATMENT SYSTEMS** & due to their:

* Efficient organic matter removal,
* High nutrient capturing capacity,
* Low construction, O/M cost,
* Low energy demand, and
* High potential for creating biodiversity.

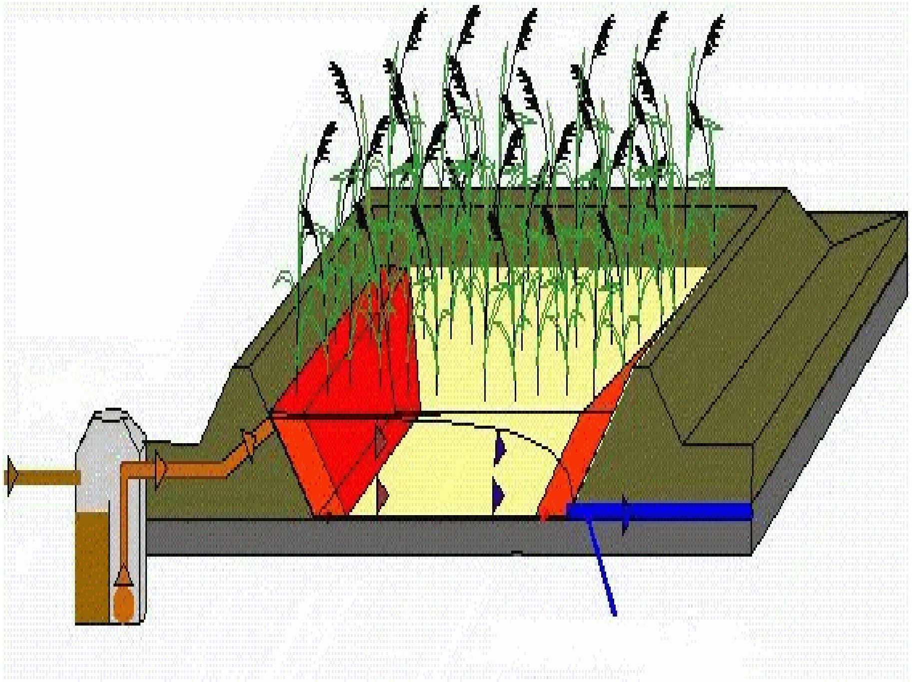
Pombia, Crete.

CONSTRUCTED WETLANDS (CWs)

can play an important & vital role in Water Resources Management.

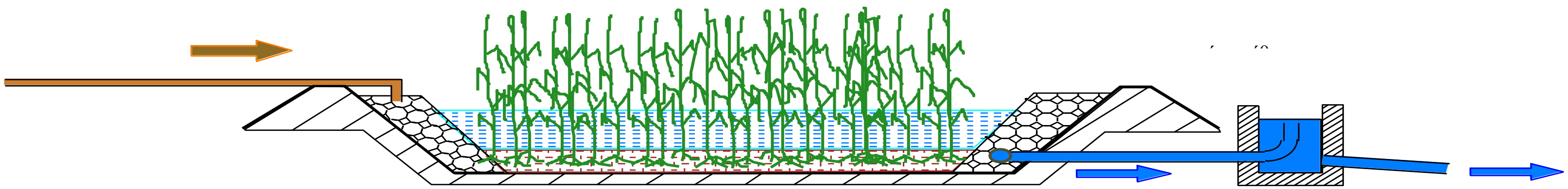
CONSTRUCTED WETLAND APPLICATIONS

- Sewage Treatment
- Industrial Wastewater
- Stormwater Treatment
- Agricultural Wastewater
- Acid Mine Drainage
- Sludge Destabilization
- Contaminated Leachates

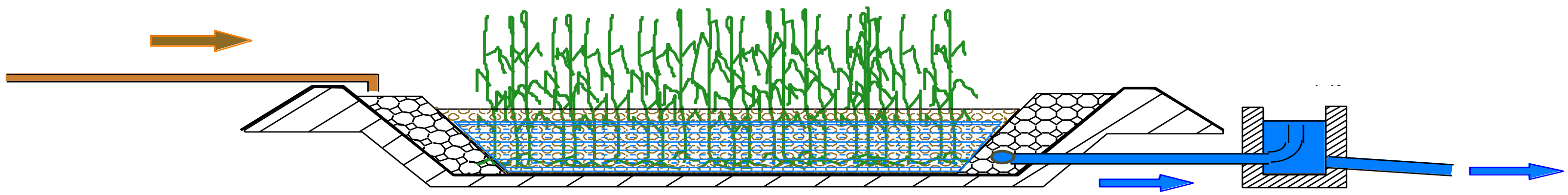


Picture taken from: IRIDRA Ltd Co., Italy.

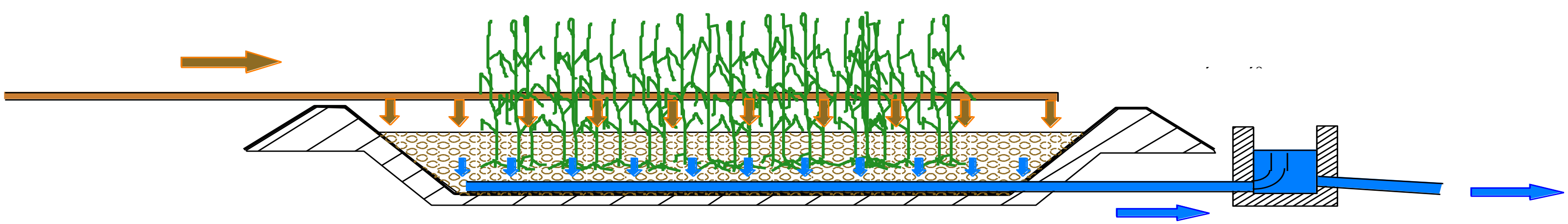
TYPES OF CONSTRUCTED WETLANDS



Free Water Surface (FWS)



Subsurface-Flow (SF)



Vertical Flow (VF)

ADVANTAGES of CWs

- Reliable TSS, COD, N treatment efficiency
- Simplicity of the method
- Low construction cost
- No need for high technological equipment
- Low energy maintenance
- Formation of wildlife habitat
- Use of the biomass of harvested aquatic plant

DISADVANTAGES of CWs

- High land area requirements
- Breeding grounds for insects
- Climatic constraints
- Necessity of a receiving water body

POSSIBLE EXPENSES OF THE CONSTRUCTED WETLAND APPLICATIONS

- ENGINEERING DESIGN OF THE CW PROJECT,
- LAND COST,
- EXCAVATION,
- SEALING MATERIAL,
- FILL MEDIUM (SUBSTRATE),
- DISTRIBUTION & DRAINAGE PIPES,
- PLANTATION,
- WATER COLLECTION TANKS,
- SUBMERSIBLE PUMPS,
- CONTROL PANEL EQUIPMENT, and
- WORKERS.

Master of Science Degree at Middle East Technical University (METU),

Ankara, Turkey

“Feasibility of a Controlled Wetland in the Mogan-Eymir System”

(1996-1998)

Short summary of my Ph.D. study

at Middle East Technical University (METU),

Ankara, Turkey

"Domestic Wastewater Treatment in Pilot-Scale Constructed Wetlands (CWs) implemented at METU"

(February 1999-September 2004)

OBJECTIVE OF MY PHD STUDY

“to quantify the effect of

different fill mediums

on the treatment performance

of the pilot-scale subsurface cws

planted with common reed,

&

operated identically

with presettled domestic wastewater”

FILL MEDIA IN CWs

In CWs, use of a variety of **special substrates (filter media)** with physico-chemical and hydraulic characteristics like:

- higher Al, Fe, Ca content;
- higher porosity;
- suitable infiltration capacity;
- reasonable price

can result in:

- higher organic and nutrient (N & P) removal efficiencies;
- a decrease in the required surface area for CWs per capita (m^2/PE).

SPECIAL SUBSTRATES

Natural ones from the local area

sand, gravel, limestone, shale, pumice, crushed rock, zeolite, …

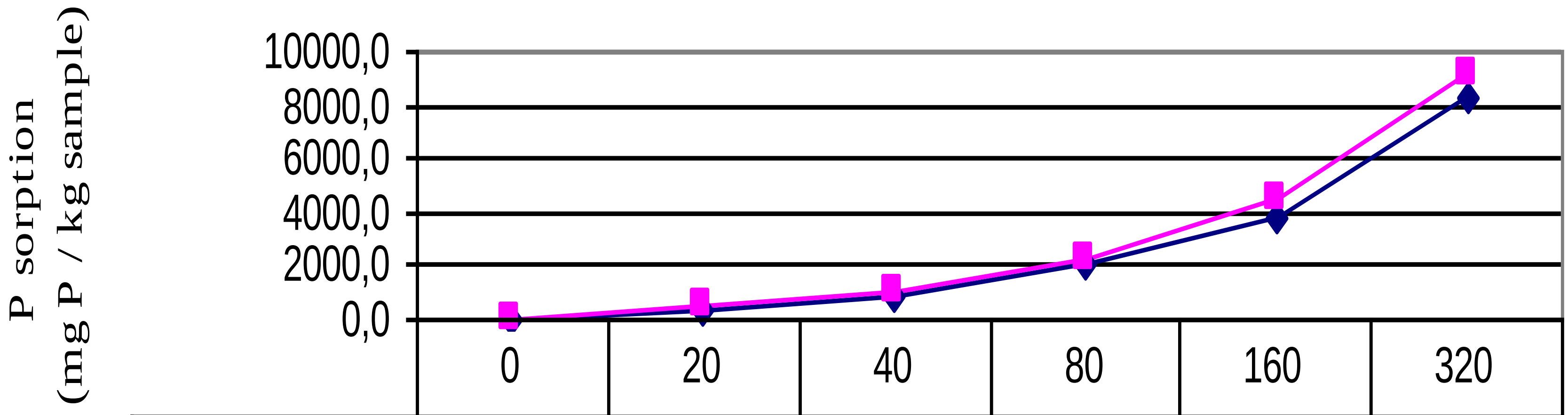
Artificial ones produced in industries as a main product

light weight aggregates like LECA

Co-produced as industrial waste

blast furnace slag, fly ash, crushed concrete, …

RESULTS OF THE ADSORPTION EXPERIMENTS



	0	20	40	80	160	320
Pumice	0,00	429,65	943,26	1987,62	3855,28	8279,50
Gran. slag	0,00	557,82	1100,57	2187,77	4441,01	9153,12

Initial P concentration (mg P / L)

Figure 1. P-Sorption Capacity of Pumice &Blast Furnace Granulated Slag

Blast Furnace Granulated Slag (BFGS):

=> Industrial waste,

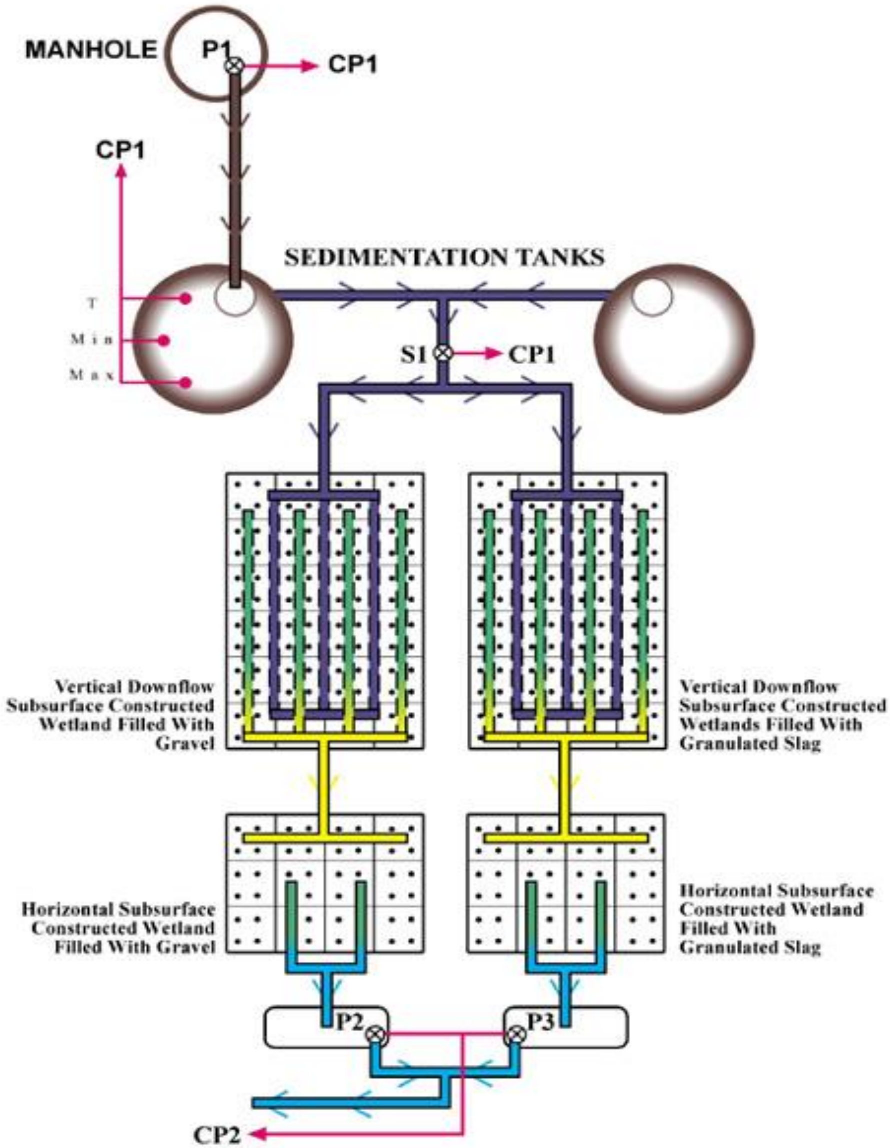
=> A porous nonmetallic co-product produced in the iron and steel industry.

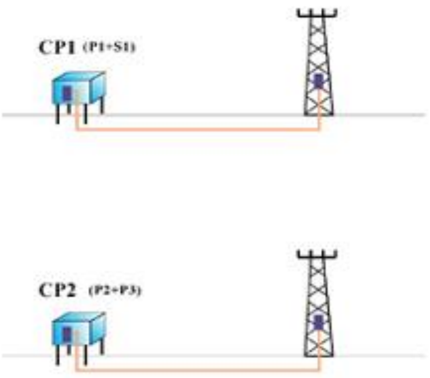
=> High P-sorption capacity as has been shown earlier in batch and column **Constructed Wetland** (**CW**) experiments (Sakadevan and Bavor, 1998; Johansson, 1999; Rustige et al., 2003).

KARDEMIR IRON & STEEL CO. , TURKEY

BLAST FURNACE GRANULATED SLAG (BFGS)

Plan View of the Pilot-Scale Constructed Wetlands implemented in METU



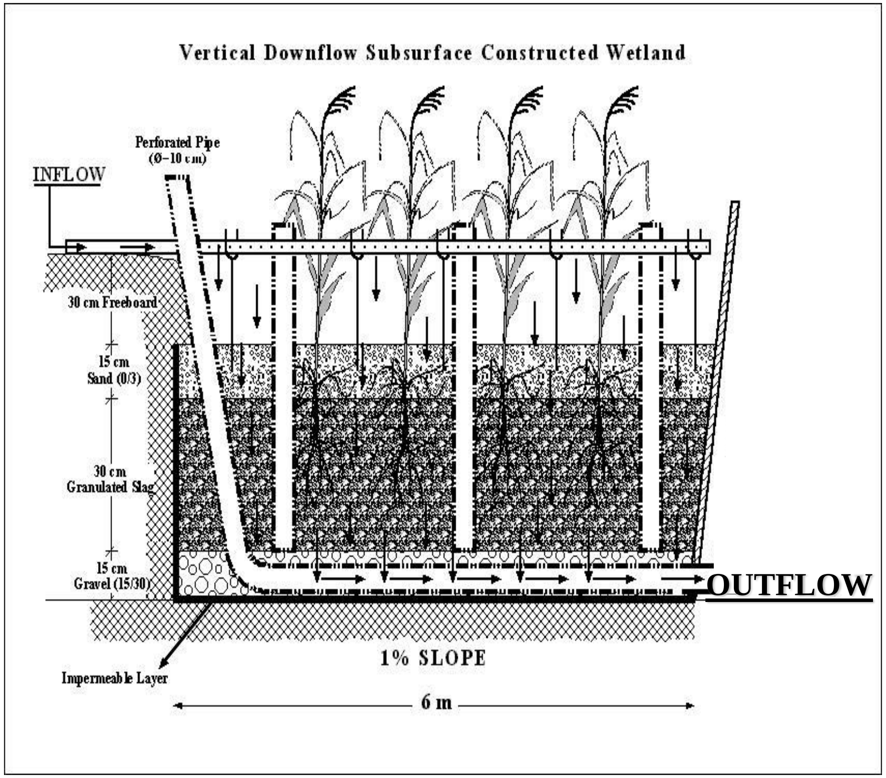


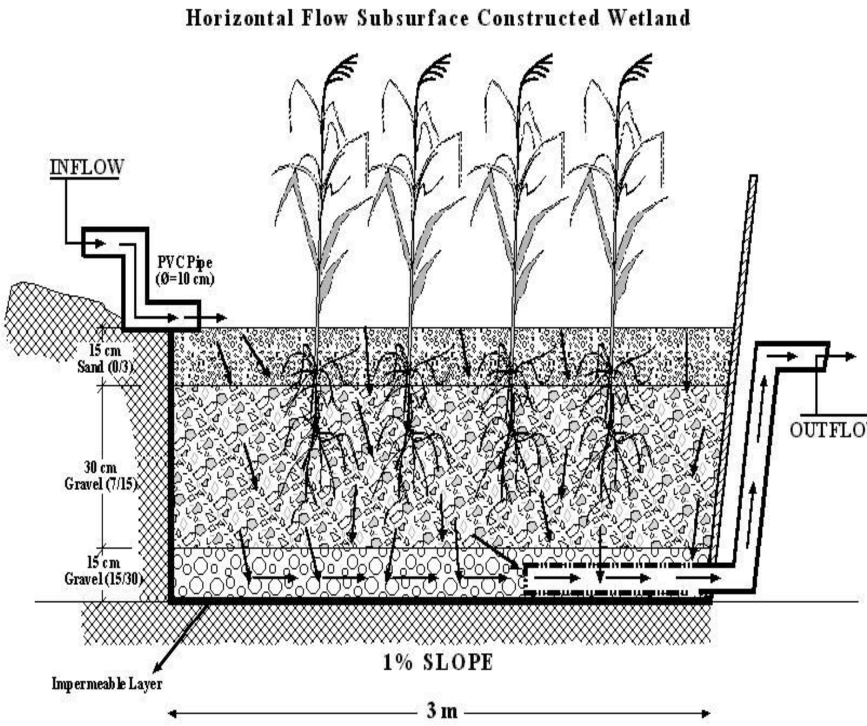
Control Panel

CP1 => Control Panel 1
CP2 => Control Panel 2
P1 => Pump 1
P2 => Pump 2
P3 => Pump 3
S1 => Selenoid Valve

Raw Wastewater
Wastewater After Primary Treatment
Treated Wastewater
Final Effluent
Cables Connected to Control Panels
Electricity Line (220 V)
Drainage Pipes

HYBRID CW SYSTEM @ METU





DOMESTIC WASTEWATER

SEDIMENTATION TANKS

Two of the old boilers have been cleaned and redesigned as sedimentation tanks.

Information about the Sedimentation Tanks:

- Length: 3.10 m
- Diameter: 1.35 m
- Effective Volume: 3.61 m3
- Detention Time: 2-3 hours

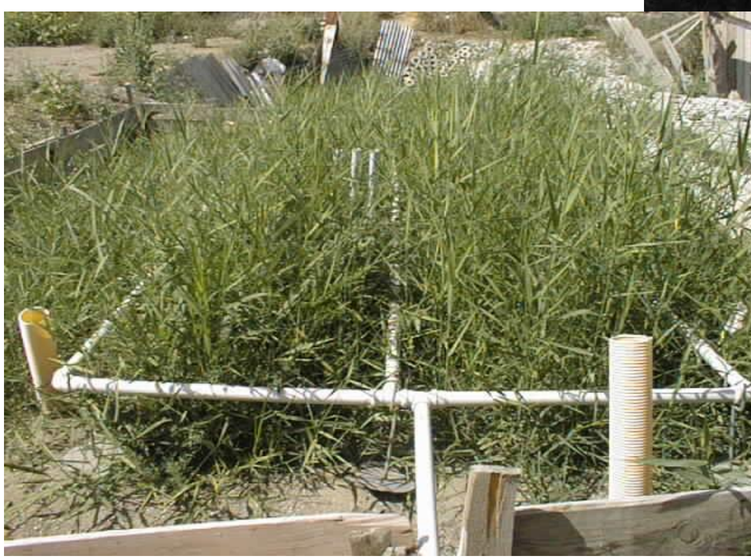
IMPLEMENTATION PHASE OF CWS AT METU



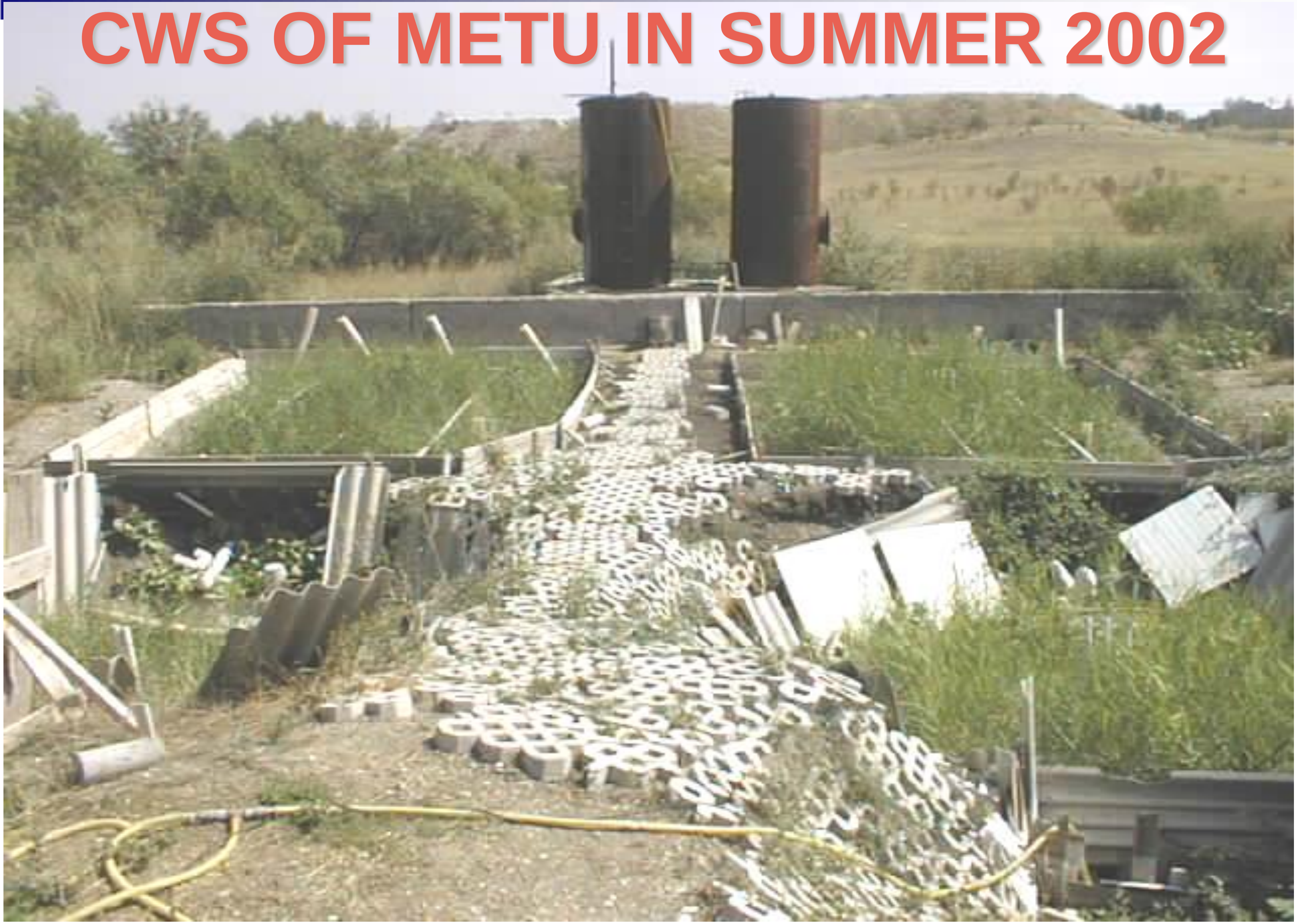


IMPLEMENTATION PHASE OF CWS AT METU

PLANTATION OF THE CWS AT METU IN 2002



CWS OF METU IN SUMMER 2002



CWS OF METU IN WINTER 2002

CWS OF METU IN SUMMER 2003

Table 1. Properties of the Pilot-Scale Subsurface Constructed Wetlands

Parameters	Pilot-Scale Constructed Subsurface Wetlands			
	# 1	# 2	# 3	# 4
Flow Type	VERTICAL DOWNFLOW	VERTICAL DOWNFLOW	HORIZONTAL FLOW	HORIZONTAL FLOW
Substratum	Sand and Gravel	Blast furnace granulated slag, sand and gravel	Sand and Gravel	Blast furnace granulated slag, sand and gravel
Width (m)	4.40	4.70	3.70	3.30
Length (m)	6.30	6.40	3.80	4.20
Area (m^2)	27.72	30.08	14.06	13.86
Discharge (m^3/d)	3	3	3	3
HLR (mm/d)	0.11	0.11	0.22	0.22
Plant Type	*P.australis*	*P.australis*	*P.australis*	*P.australis*

Table 2. Parameters Monitored and corresponding Experimental Methods

PARAMETER	METHOD
Biochemical Oxygen Demand, BOD_5	Oxygen Demand (Biochemical)
Chemical Oxygen Demand, COD	Micro COD, Hack Method (Range:0-1,500 mg/L)
Total Suspended Phosphorous, TP	Persulfate Digestion Method (0-1.5 mg/L)
Orthophosphate-P, PO_4-P	Ascorbic Acid Method (0-1.5 mg/L)
Ammonium-N, NH_4+-N	Direct Nesslerization Method (0-1.2 mg/L)
Nitrate-N, NO_3--N	Brucine Method (0.1-1 mg/L)
Total Nitrogen, TN	Persulfate Digestion Method (0.1-1 mg/L)
Total Suspended Solids, TSS	Vacuum Filtration (0.45µm, 47 mm Cellulose Filter Paper)
Fecal Coliform	M-FC Nutrient Pads (Incubation @ 44.5°C for 24 h)

COST ANALYSIS

Table 3. Expenses of the Project (2002) (for treatment of 6 m^3/d)

Expenses	Quantity	Unit Cost (US $)	Total Cost (US $)
Excavation	12 hours	$20.00 / hr	$240.0
Nylon for Sealing	10 m x 42 m	$2.50 / m	$105.0
Sand	30 m^3	$11.00 / m^3	$330.0
Gravel	32 m^3	$11.00 / m^3	$330.0
Transportation of slag	32 tonnes	$7.30 / tonnes	$235.0
Drainflex and PVC pipes	200 m	$1.60 / m	$320.0
Submersible Pumps	3	$120.00 / each	$360.0
Control Panel & Connections	---	---	$500.0
Workers	33	$12.0 / 8 hr	$396.0
TOTAL*			**$2,816.0**

* Plantation cost was not included!!! Slag was a gift of the Iron and Steel Company!!

ANALYSIS FOR DETERMINATION OF THE PLANT CONTENT





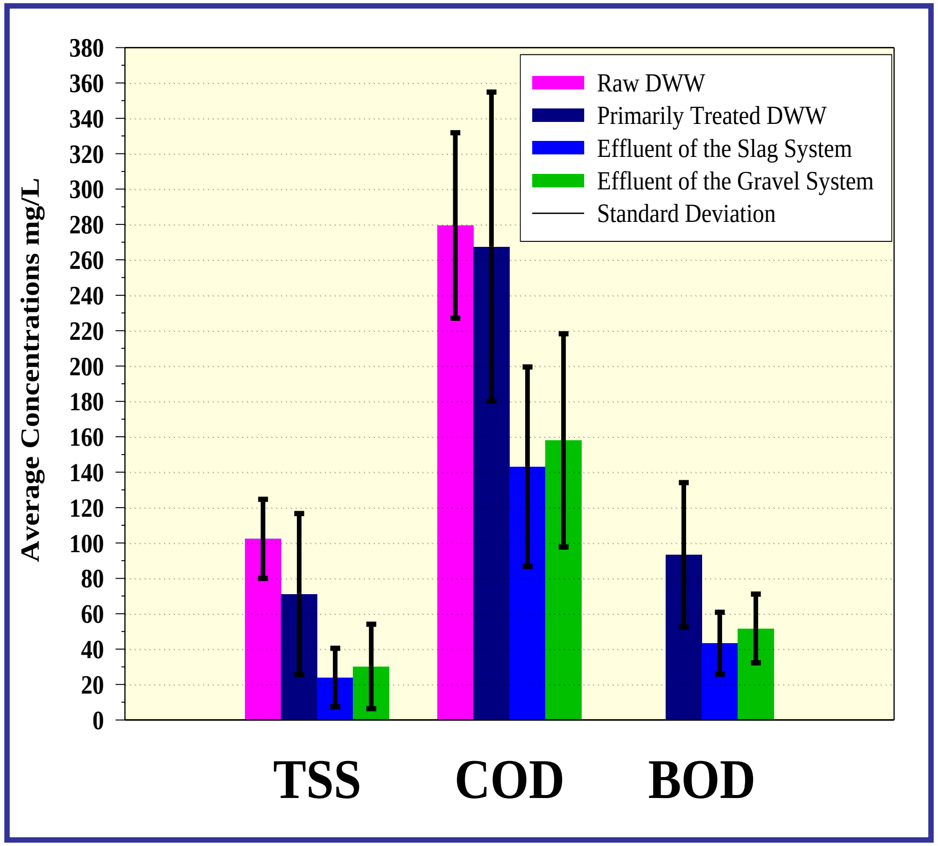

DETERMINATION OF THE SUBSTRATE CONTENT

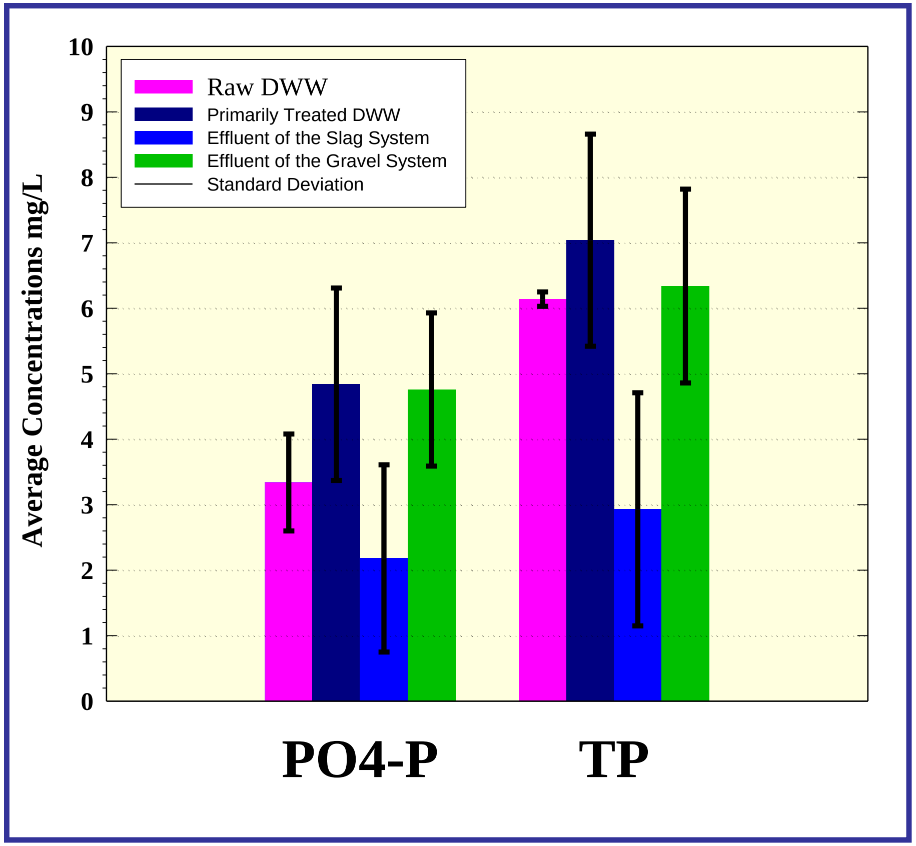


- The substrate analyses were performed according to the methodologies adopted by Kacar (1972).

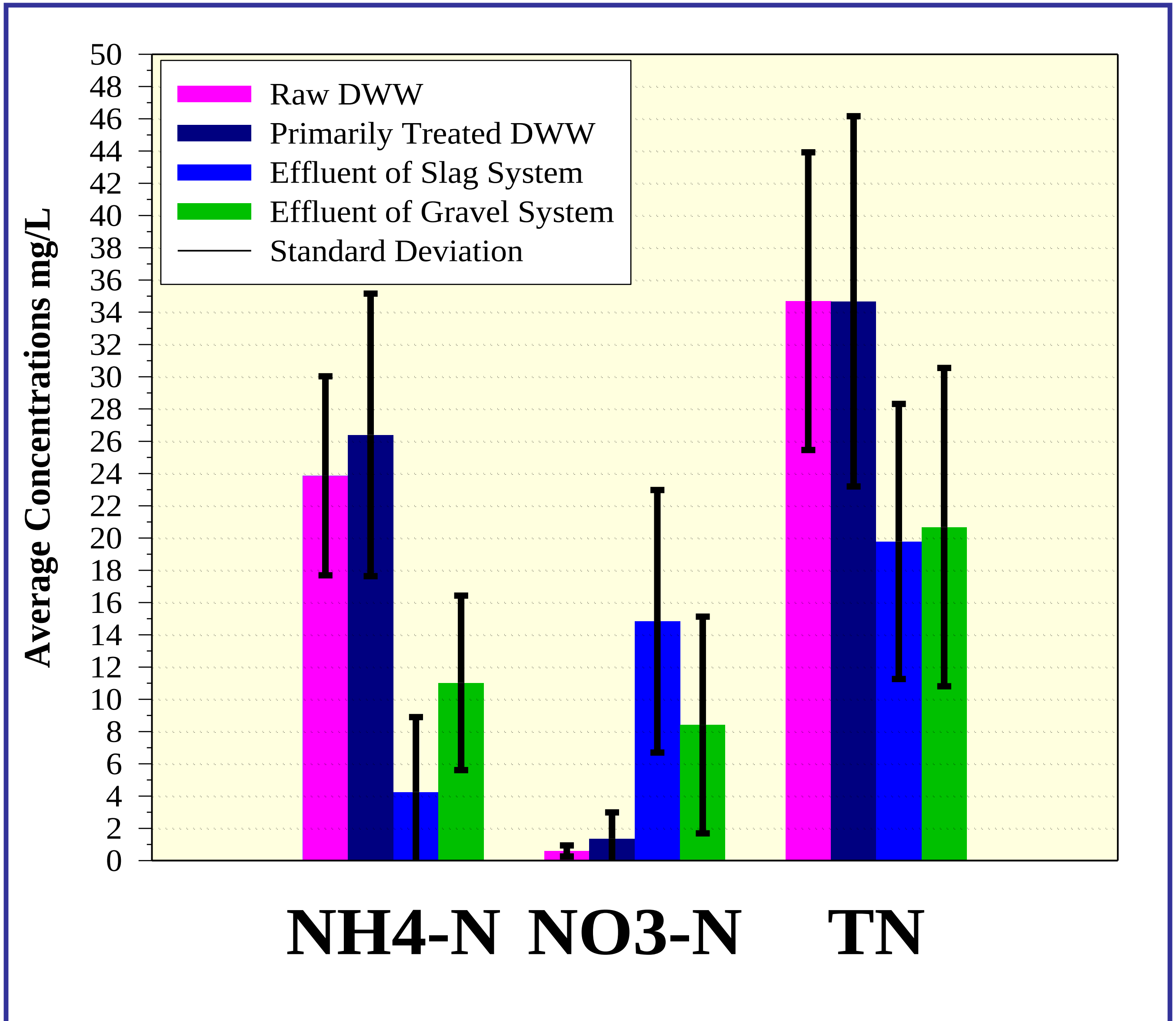
- The chemical extraction methodology proposed by Chang and Jackson (1957) and modified by Hartikainen (1979) was used in this study to fractionate the inorganic P-forms retained by sand and slag layers of the wetlands.

AVERAGE ANNUAL CONCENTRATIONS





AVERAGE ANNUAL CONCENTRATIONS



ANNUAL AVERAGE RE% OF VFCWs IMPLEMENTED @ METU

RE (%):	SLAG	GRAVEL
TSS:	63 ± 22	59 ± 20
COD:	47 ± 18	44 ± 21
PO_4^{3-}-P:	45 ± 31	3 ± 14
TP:	45 ± 28	8 ± 15
NH_4^+-N:	84 ± 12	53 ± 14
TN:	45 ± 21	39 ± 15

CONCLUSIONS

*This study indicated that properly designed and operated subsurface flow **CWs** have a **great potential for secondary and tertiary wastewater treatment in Turkey**.

*As being one of the leading studies for implementation of the Pilot-Scale CWs in Turkey for treating the real domestic wastewater produced by **60 PE (3 m^3/d)**, this study has contributed to the understanding of how subsurface flow CW systems performed under the prevailing climate in Ankara.

Further Success

“Implemantation of the Full-Scale Hybrid CWs for 450 PE in Şanlıurfa-Viranşehir in 2003 (SouthEast of Turkey)”

Integrated Preventive Environmental Project for Municipalities (IPEMM)

IPEMM has been carried out by CEE since 2000 as an **awareness raising, training** and **implementation** programme for municipalities.

IPEMM is supported by the **Swiss Agency for Development and Cooperation (SDC).**

IPEMM

- **IPEMM – I**
  Training
  (2000-2002)
- **IPEMM – II**
  Implementation
  (2003-2004)

Viransehir Constructed Wetland Project - CWP

CWP is carried out in cooperation between the technical staff of CEE and Municipality of Viransehir and comprises

- the design,
- construction,
- operation,
- monitoring

of a constructed wetland system for the treatment of municipal wastewater (average 40 m^3/day) which is equivalent to the wastewaters of approximately 400 inhabitants.

Population: 120,200

Area: 345 km^2

Yearly average temperature: 26.1°C (~41°C in summer)

Preliminary Studies (cont'd)

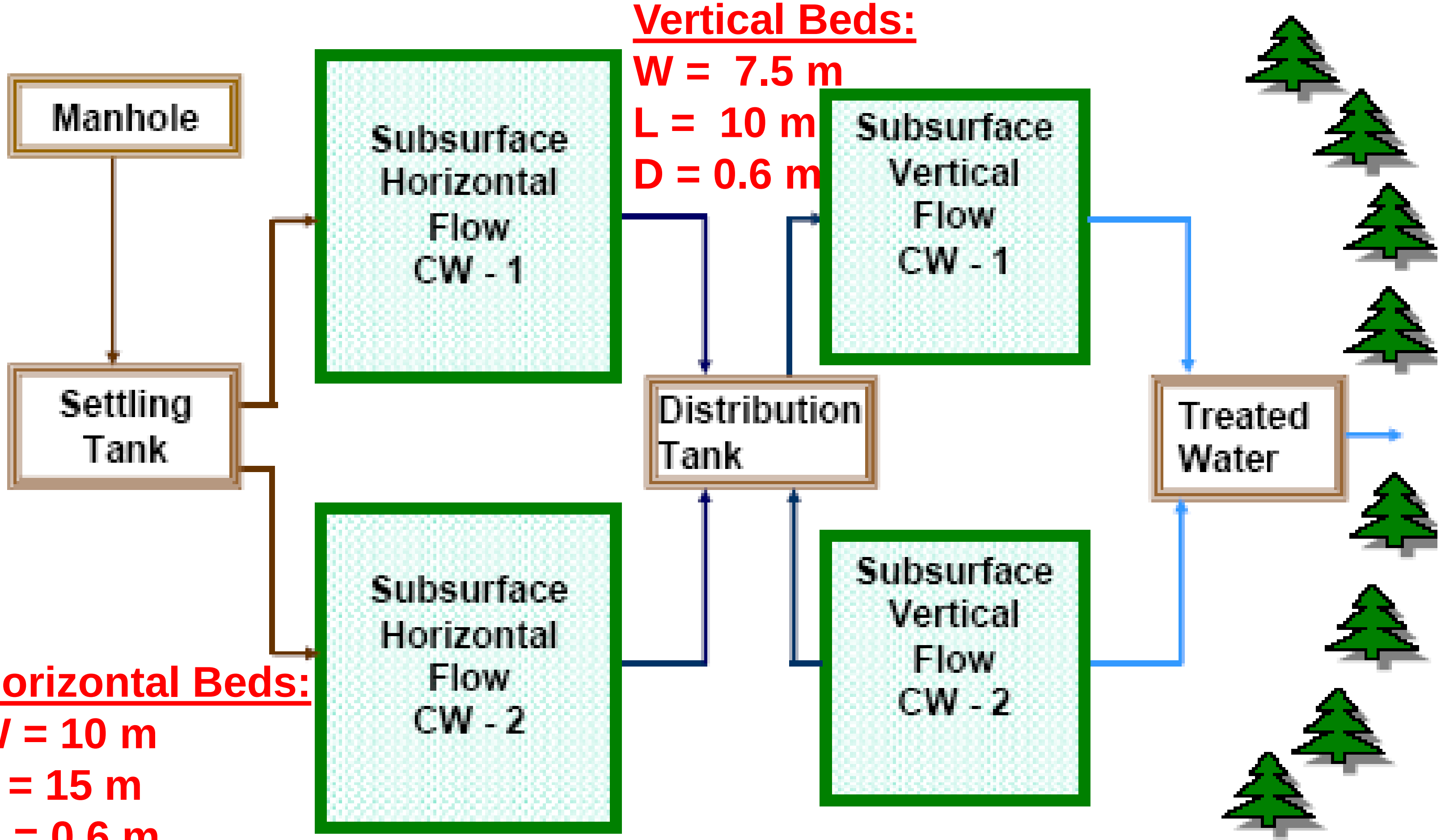
Wastewater Analyses*

Parameter	Wastewater Sample From Viransehir Sewer System	Typical Values**	Unit
BOD_5	110 ± 36	200	$mg.L^{-1}$
COD	302 ± 93	500	$mg.L^{-1}$
TSS	91 ± 37	200	$mg.L^{-1}$
NH_3-N	10.53 ± 8.29	12	$mg.L^{-1}$
NO_3^--N	13 ± 3.5	0	$mg.L^{-1}$
PO_4^{3-}-P	4.87 ± 1.86	5	$mg.L^{-1}$
Conductivity	1277 ± 427	470	$\mu mho.cm^{-1}$

* Standard Methods (AWWA, 1999), ** Tchobanoglus, 1991; Arceivala, 2002

ŞANLIURFA-VİRANŞEHİR CW

Vertical Beds:
W = 7.5 m
L = 10 m
D = 0.6 m

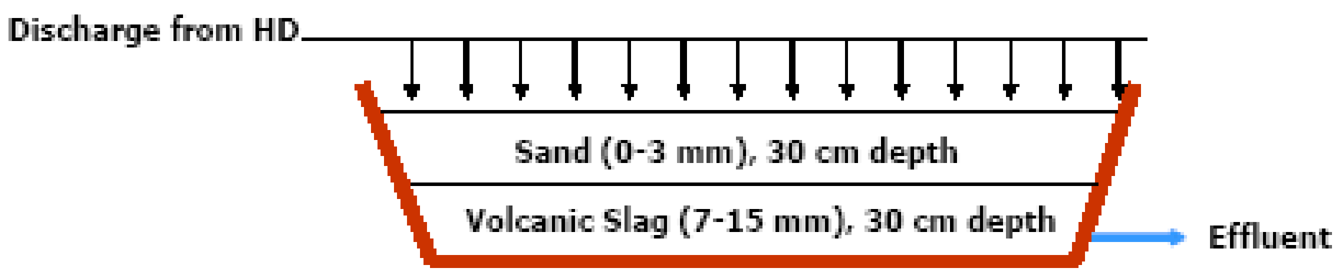


Horizontal Beds:
W = 10 m
L = 15 m
D = 0.6 m

Intermittently Loaded (4 times/day)
Average Flow Rate: 40 m^3/d HLR = 100 mm/d

ŞANLIURFA-VİRANŞEHİR CW

Substrates used in HD1 and HD2



Substrates used in VD1 and VD2

ŞANLIURFA-VİRANŞEHİR CW

2004

ŞANLIURFA-VİRANŞEHİR CW

2004

ŞANLIURFA-VİRANŞEHİR CW
Treatment Performance
(2004 December Values)

Parameter	Inflow (mg/L)	Outflow (mg/L)
BOD_5	110 ± 36	11
COD	302 ± 93	37
TSS	91 ± 37	1
NH_4-N	10.53 ± 8.29	0.07
NO_3^--N	13 ± 3.5	-
PO_4^{3-}-P	4.87 ± 1.86	6.77

?????

What about establishing my own Start-up Company on Constructed Wetlands in Turkey?

(2003)

According to my Business Plan: Having a Private Company on CWs in Turkey (2003):

Not Feasible!!

Post-Doc Studies (2004-2007)

Years	Degree (*)	University	Subject
2005-2007	Second Post-Doc Study **(EU Marie Curie IEF Proje No:515515: *ONUREM*)**	**University of Natural Resources and Applied Life Sciences (BOKU-SIG), Vienna, Austria.**	Constructed Wetlands
2004-2005	First Post-Doc Study **(AB “Support Programme of MEDREUNET” Burslusu)**	**Technical University of Crete, Chania, Crete, Greece.**	Constructed Wetlands

Short summary of my first Post-Doc Study

at Technical University of Crete,

Chania, Greece

(E.U. Project INCO-CT-2003-502453)

"Manual of Practice on CWs for Wastewater Treatment and Reuse in Mediterranean Countries"

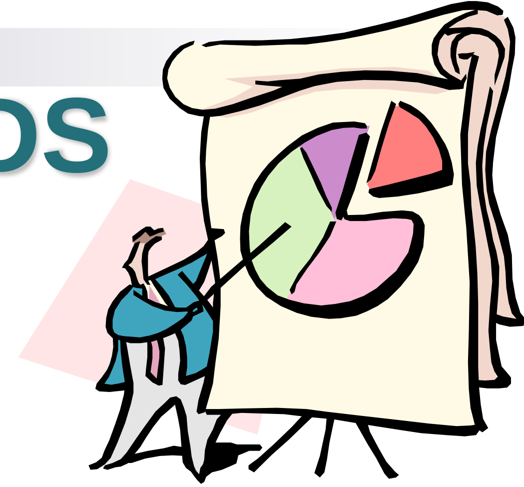
(September 2004-March 2005)

OBJECTIVE OF THE

“MANUAL of PRACTICE on CWs for MEDITERRENEAN COUNTRIES”

“to provide theoretical & practical knowledge of the CW technology to the engineers, researchers and stakeholders, who are interested in designing, constructing, operating & using CWs as an alternative option for water quality enhancement and reuse, especially for small agglomerations in rural areas of several Mediterranean countries”

MATERIALS AND METHODS



Theoretical background on CWs has been summarized based on the existing literature.

CW case studies conducted in some of the Mediterranean countries (Portugal, Spain, France, Italy, Slovenia, Croatia, Greece, Turkey, Israel, Palestine, Egypt, Morocco) have been reviewed, summarized and evaluated.

Wetland researchers from Mediterranean countries have been contacted and asked to contribute their experiences on the design; application and monitoring of the CWs.

"Good Practice Guidelines" have been developed for future CW applications in the Mediterranean countries.

- **The manual is available on the website:**

www.researchgate.net: Elif Asuman Korkusuz

AIM OF THE “GOOD PRACTICES GUIDELINES”

“to avoid repetition of the bad experiences gained during the former CW applications

&

to minimize failures, which can be faced during application and O/M of CWs while implementing them in Mediterranean countries ”

CONTEXT OF THE MANUAL

Totaly: ~400 pages

1. **INTRODUCTION (3 pg)**

2. **HISTORICAL DEVELOPMENT OF CWs (45 pg)**

   2.1. General Information on Natural Wetlands

   2.2. Functions of Natural Wetlands

   2.3. CWs for Waste Management and Water Quality Enhancement

   2.4. Advantages of Wetlands over Conventional WWT Systems

   2.5. CW Applications

   2.6. Classification of CWs

   2.7. Removal Mechanisms in CWs

CONTEXT OF THE MANUAL

3. CW STUDIES IN THE MEDITERRANEAN REGION (60 pg)

3.1. CW Studies in Mediterranean-Europe
3.2. CW Studies in Eastern Mediterranean
3.3. CW Studies in North Africa

4. GOOD PRACTICES GUIDELINES (36 pg)

4.1. Design and Practical Application of the CWs at the Field
4.2. Operation/Maintenance of the CWs in Mediterranean Countries

5. END RESULTS AND CONCLUSIONS (6 pg)

CONTEXT OF THE MANUAL

6. **RECOMMENDATIONS FOR FUTURE CW APPLICATIONS FOR MEDITERRANEAN COUNTRIES (4 pg)**

7. **REFERENCES (22 pg)**

8. **APPENDICES (~ 100 pg)**
   8.1. Templates of the Case Studies
   8.2. Design Criteria of the French Vertical Flow CWs treating Raw Sewage
   8.3. Contact List of the CW Researchers

Some of the Outcomes of the Manual (in 2005)

- The great majority of **Governments or relevant agencies** of the Mediterranean countries **did not accept CWs** as a state of treatment technology, **when it was first introduced**.

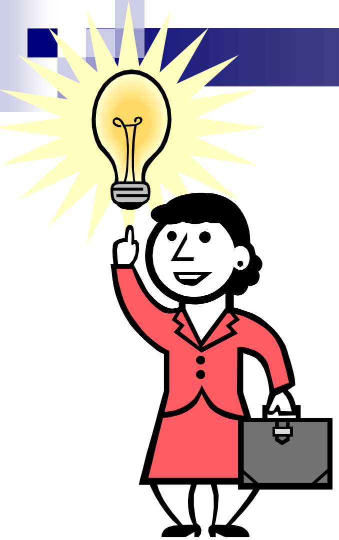
- However, at the end of 1980s, **several research studies on CWs have started** in most of the Mediterranean countries by **private companies, research institutes and universities**.

- As a result, in the middle of the 1990s, **several installations of CW applications** treating wastewater originated from the **individual houses, small agglomerations, industries, agricultural runoff, farms, tourist facilities**, etc. existed in the Mediterranean Region.

- The **industrial wastewaters** treated in CWs in Mediterranean countries were: **food processing waste** (vegetable, oil, wine, cheese, beer, dairy farms), **car-washers** and **small breeding farms**, **treatment of landfill leachates** and **heavy metals**.

- **Hybrid systems**, (combinations of VF & HSSF CW systems or FWS & SSF), were **gaining popularity** in the recent years.

- Moreover, **addition of the different types of CW** to the treatment line of the **Conventional Treatment Plants** became an important issue.



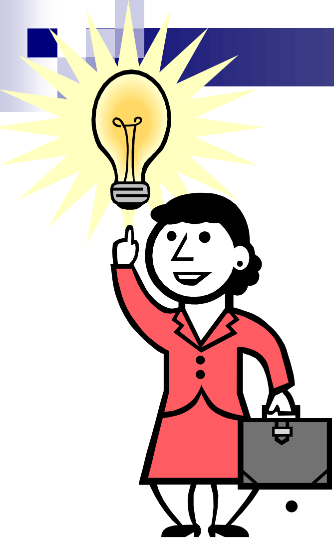
SOME RECOMMENDATIONS FOR FUTURE CW RESEARCH STUDIES IN MEDITERRANEAN REGION

* Wetland researchers in Mediterranean countries must **identify their own specific research needs** and **develop appropriate strategies based on local parameters**.

* To develop **proper design & operation criteria specific** to each of the **Mediterranean countries**, **interdisciplinary teams** should be formed among the **specialists** coming from different disciplines (e.g. engineering, life sciences and social sciences).

* They should be **able to handle** the current and future wastewater treatment & reuse problems using the CW technology in Mediterranean Region.

* These teams may be both **national & international,** & develop **action-oriented cooperation**.



SOME RECOMMENDATIONS FOR FUTURE CW RESEARCH STUDIES IN MEDITERRANEAN REGION

- Further pilot and full-scale CW demonstration projects for treatment of various types of wastewater should be developed and applied in the Mediterranean countries.
- In these projects, several experiments should be performed and monitored under varying conditions in different parts of the Mediterranean basin.
- Realistic economic analysis must be conducted to determine whether CW treatment technology is really feasible or not for a given project location and its prevailing conditions.
- A close cooperation and technical-knowledge exchange should be encouraged between the private companies, research institutes, universities, authorities and the local technical services in charge of the assessment of performances of CWs.

RECOMMENDATIONS FOR FUTURE CW APPLICATIONS IN THE MEDITERRANEAN BASIN

Constructed Wetland researchers in Mediterranean countries should ask themselves the followings before deciding to implement a CW in their local area:

- Is the CW technology an appropriate and feasible option for water quality enhancement in my area?
- What are my specific needs to solve the problem?
- How can I develop appropriate strategies based on local parameters and using a coordinated multidisciplinary approach?
- How can I learn the experience obtained by the wetland researchers, who have worked worldwide in different places?

E.U. Marie Curie IEF Project,

SIG-BOKU, Vienna, Austria

(2005-2007)

Short summary of the E.U. Marie Curie IEF Project,

SIG-BOKU, Vienna, Austria

ONUREM (Project No: E.C. 515515)

"Optimization of NUtrient REMoval in Constructed Wetlands using Special Substrates and Numerical Simulation"

(August 2005-August 2007)

Introduction to the E.C. Project: ONUREM (2005-2007)

- Intermittently-loaded vertical subsurface flow (VF) CWs are state-of-the-art in Europe mainly to remove OM, TSS, ammonium, and microbiological contamination.

- The large surface area requirement (3-10 m^2/PE) to meet the specified quality objectives makes it sometimes impossible to set up these reed beds in small/medium communities, where land is at a premium.

- Thus, wetland researchers recently have focused on the **optimization of VF CWs** and in particular on the **use of special substrates (fill mediums) for enhanced removal of nutrients (N&P)**.

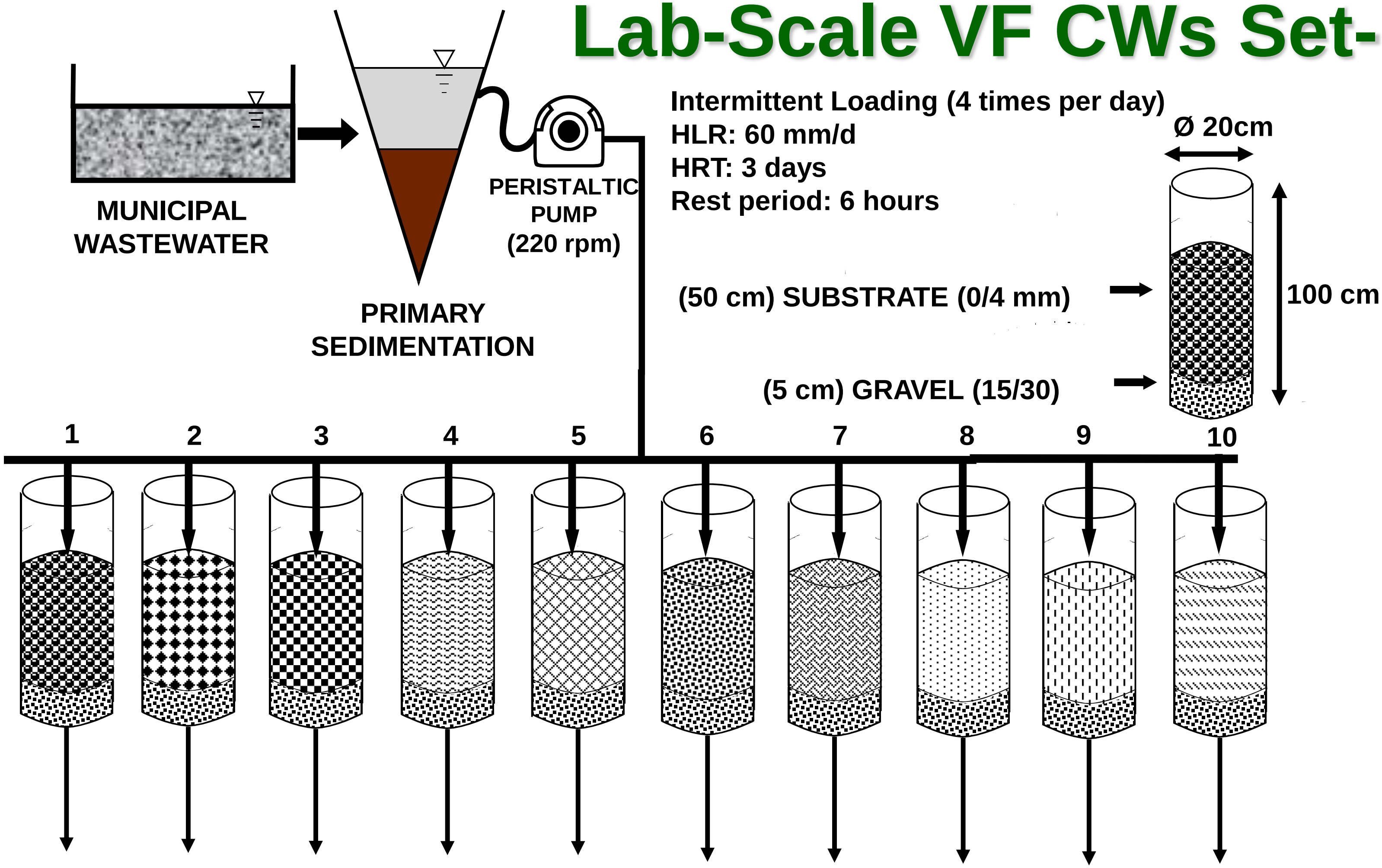
- A special substrate can be either **natural** that is provided mostly from the local area (e.g. *sand, gravel, limestone, shale, crushed rock, pumice, zeolite*, etc.) or **artificial** that is produced in some industries as main products (e.g. *light weight aggregates like LECA*) or **co-produced industrial wastes** (e.g. *blast furnace slag, fly ash, crushed concrete*, etc.).

OBJECTIVE OF THE "ONUREM"

" to quantify the effect of different natural & artificial substrates that are commercially available in the markets of Turkey & Austria

on the removal performance of nutrients (N, P) of the lab-scale VF CWs to be operated identically with municipal wastewater at the Technikum of BOKU, Vienna, Austria"

Lab-Scale VF CWs Set-Up



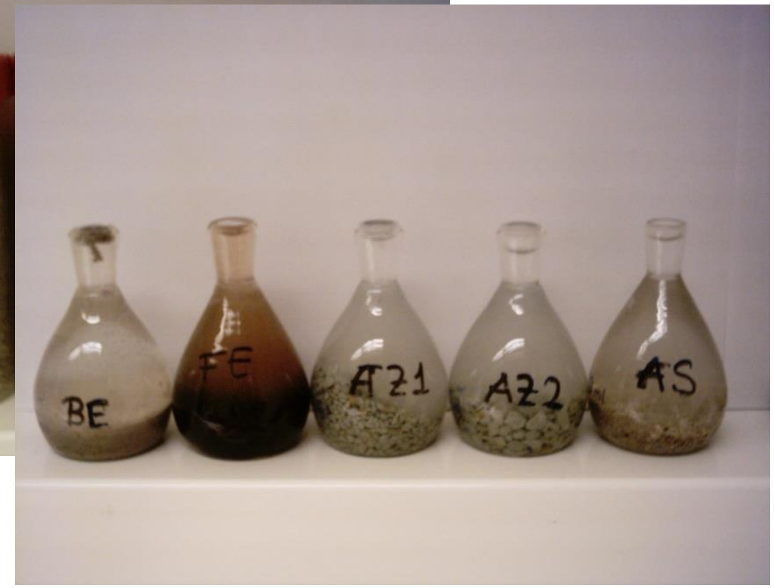
SUBSTRATES ORIGINATING FROM TURKEY:

1) BLAST FURNACE GRANULATED SLAG (SL)
2) PERLIT (PE)
3) PUMICE (PU)
4) TURKISH SAND (TS)
5) TURKISH ZEOLITE (TZ)

SUBSTRATES ORIGINATING FROM AUSTRIA:

6) CRUSHED-CONCRETE (BE)
7) FERROSORP (FE)
8) AUSTRIAN ZEOLITE 1 (1.5-2.0 mm) (AZ1)
9) AUSTRIAN ZEOLITE 2 (4.0-5.0 mm) (AZ2)
10) AUSTRIAN SAND (AS)


TZ
AZ1
AZ2

AS

BE
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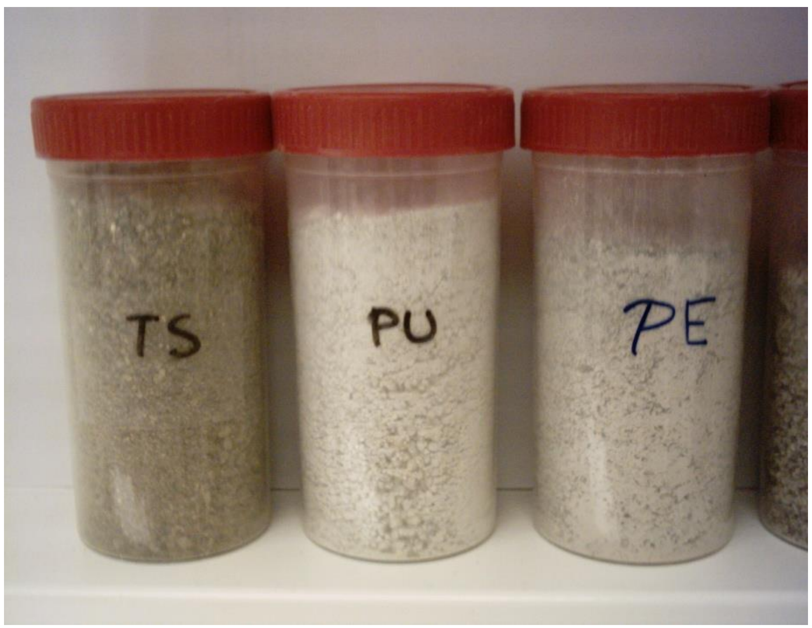
TS
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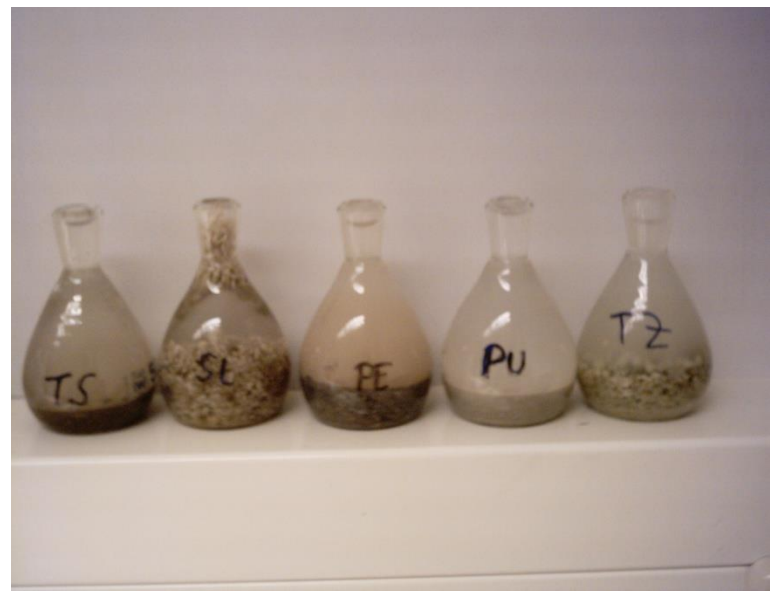

TS
PE
PU
TZ


Das Verweilen
unter hängender Last
DIGITAL


Vorsicht
schwebende
Last
Das Verweilen

CONCLUSIONS of ONUREM

- During the start-up period**, the ammonium removal rates** were unstable and differing from each other, but afterwards they became relatively more stable and similar (except for crushed-concrete, **no statistical difference at a confidence level of 95%).**

- For the 8 months of monitoring period, except for crushed concrete, **9 of the substrates removed ammonium with an efficiency of almost over 99.5%,** although the substrates had different physico-chemical properties.

- It was again observed that only using the batch-scale experiments, one can not predict about the future nutrient removal performance of a filter that is operated under real conditions since the physico-chemical and hydraulic characteristics are changing with time.

- The results of this research, where **real municipal wastewater** was used, are thought to be **more realistic** if compared to the results of the lab-scale experiments, where synthetic wastewater or only N or P solutions were used.

Simulation Studies for Calibration of the Flow and Single-Solute-Transport Model

Flow Rate Measurements and Tracer Studies

- Influent and effluent flow rates of 10 lab-scale VSSF have been measured.
- Tracer studies (KCl dissolved in tap water) have been conducted to understand single-solute-transport characteristics of the filter substrates.
- Electrical conductivities (mS/cm) of influents and effluents have been measured online and recorded with a data logger.

Simulation Studies with the model CW2D

The multi-component reactive transport model **Constructed Wetlands 2-Dimensional** (**CW2D**) that was developed by Günter Langergraber (2001) from BOKU Vienna Austria, has been used for simulation studies.

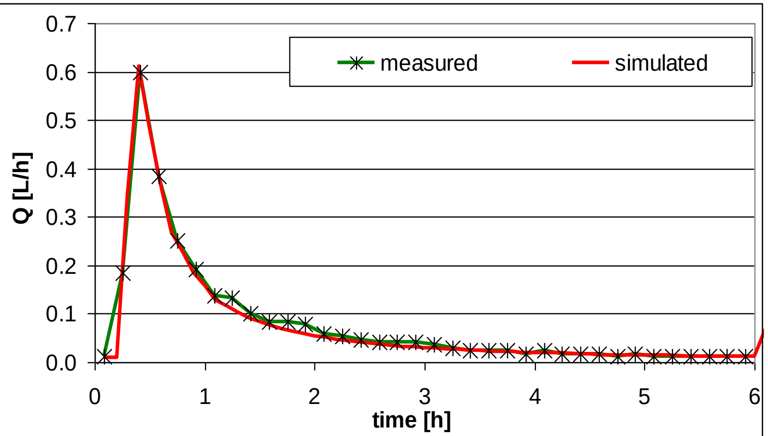
1) **Measured values of physico-chemical parameters** (e.g. density, porosity, saturated hydraulic conductivity, etc.) **of the substrates** & **data of the tracer studies** have been used as **input parameters** for simulation of the **CW2D**.

2) The **flow model** has been **calibrated** using **effluent flow rate measurements** of the lab-scale CWs.

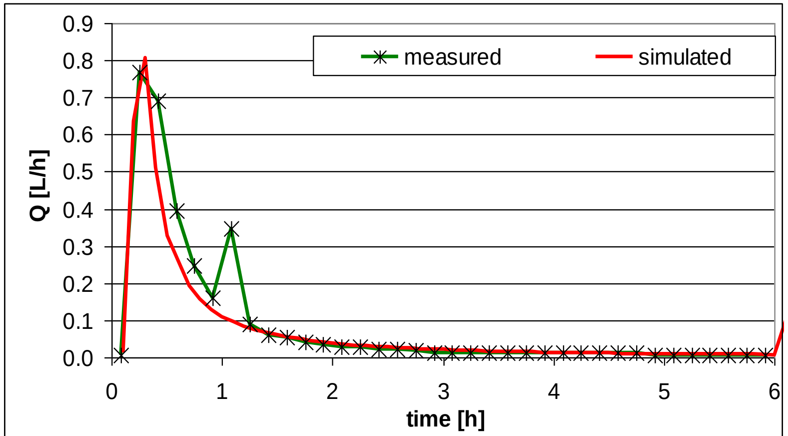
3) **Simulated results** of the **CW2D** for different substrates have been **validated with the measured data** obtained from the tracer studies.

4) **Measured and estimated hydraulic parameters** that are obtained via simulation studies have been **compared** each other.

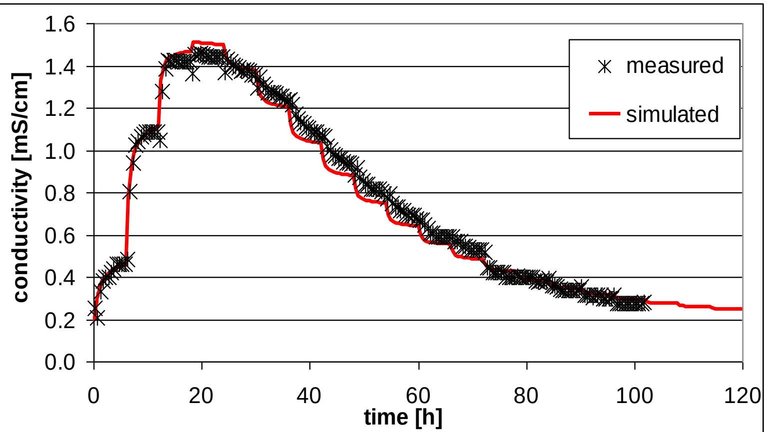
EXAMPLE: Simulation Results for Turkish Zeolite & Austrian Zeolite 1



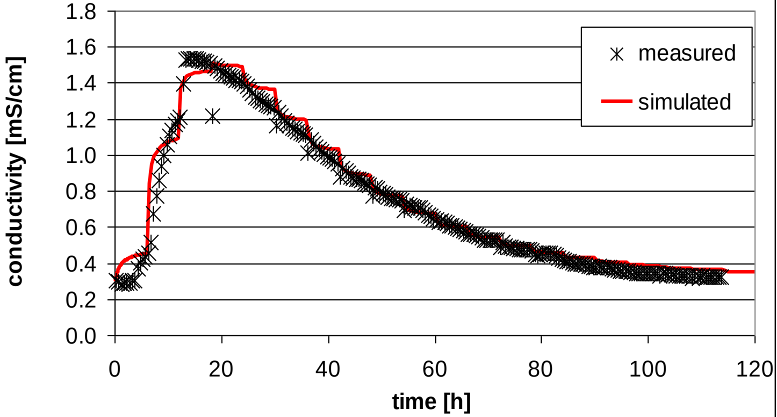
Effluent Flow Rate of TURKISH ZEOLITE



Effluent Flow Rate of AUSTRIAN ZEOLITE 1



Tracer Studies for TURKISH ZEOLITE



Tracer Studies for AUSTRIAN ZEOLITE 1

CONCLUSIONS FOR SIMULATION STUDIES

- **Simulated effluent flow rates have showed very close matches to the measured effluent flow rates.**

- **Tracer simulations have represented the measured ones very well.**

- **The success of the simulation results are dependent on how accurate hydraulic properties of the substrates in CWs can be measured & described.**

- **Findings of this work have increased the available input model data for different filter media for CW2D so that the CW2D can be used as a practical design tool to optimize the size of CWs.**

CONCLUSIONS

As the "Manual of Practice on CWs in Mediterranen Countries" (Korkusuz, 2005) has pointed out, CWs can play an important and vital role in water resources management and sustainability in the Mediterranean basin.

However, CW technology is NOT a "ZERO-ENERGY and FIX&FORGET" wastewater treatment system.

Moreover, CWs are NOT "simply made up with sands, stones, pipes and magic plants eating all the pollutants". The design & its application needs sophisticated interdisciplinary approach.

Nevertheless, my own experience on CWs indicated that properly designed & operated CWs have a great potential for secondary and tertiary wastewater treatment in Turkey and in devoloping countries, in the near future.

THANK YOU FOR YOUR ATTENTION!!!

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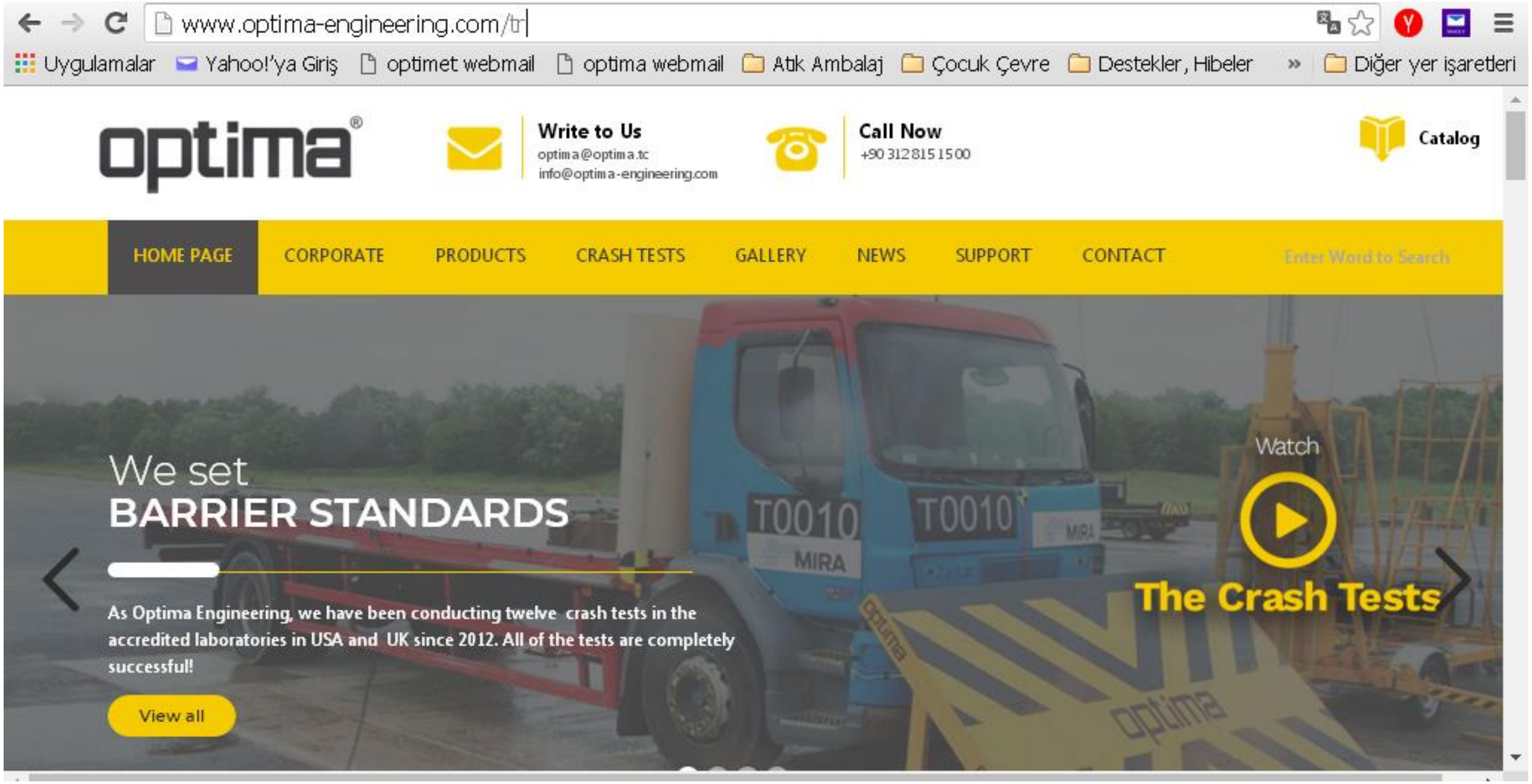

OPTİMET Engineering Enve. Technologies Ltd. Co./Ankara

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Some communities can treat their wastewater in a suitable way, others lack convenient treatment systems, thus **untreated wastewater is discharged** into the natural environment.

As a result, even in the 21st century, people can still be facing with **environmental and sanitary problems**.

Since most of the **Conventional (intensive) Treatment Systems** are technologically **complex, financially expensive, energy and labour intensive,** many communities **CANNOT AFFORD** the construction and operation of **Centralized Treatment Systems**.

Ankara Conventional Wastewater Treatment Plant

END RESULTS

- The great majority of **Governments or relevant agencies** of the Mediterranean countries **did not accept CWs** as a state of treatment technology, **when it was first introduced**.

- However, at the end of 1980s, **several research studies on CWs have started** in most of the Mediterranean countries by **private companies, research institutes and universities**.

- As a result, in the middle of the 1990s, **several installations of CW applications** treating wastewater originated from the **individual houses, small agglomerations, industries, agricultural runoff, farms, tourist facilities**, etc. existed in the area.

- The **industrial wastewaters** treated in CWs in Mediterranean countries are:
  food processing waste (vegetable, oil, wine, cheese, beer, dairy farms),
  car-washers and **small breeding farms**, **treatment of landfill leachates** and **heavy metals**.

- **Hybrid systems**, (combinations of VF & HSSF CW systems or FWS & SSF), are **gaining popularity** in the recent years.

- Moreover, **addition of the different types of CW** to the treatment line of the **Conventional Treatment Plants** becomes a current issue.

END RESULTS

- The **majority of the CW systems** build in the Mediterranean countries are **SSF CW** system. In **Portugal** and **Italy**, the **HSSF** systems are the most preferred systems, whereas in **France**, the most favourite systems are **VF**.
  FWS studies are performed in **Greece, Israel, Palestine** and **Egypt**.

- However, there are **still no regulations specific to CWs** **in most of the Mediterranean countries except for France and Italy**, which have developed their guidelines in the 2000s.

- Most of **HF** and **VF systems for secondary treatment** are designed with the **specific area** of **3-5 m^2/PE** and **2-5 m^2/PE** (assuming 60 g $BOD_5.cap^{-1}.d^{-1}$), respectively.

- **FWS** are prevalently used **for tertiary treatment** with a **specific area of about 1.5 m^2/PE**, or combined, **as a final stage**, with HF and VF systems to obtain a **better pathogens removal** or to **refine the wastewater treatment** with the **aim of reusing** it.

- The **Hybrid Systems** are particularly powerful to obtain a **high nitrogen removal** with the smallest use of land (**1-2 m^2/PE**).

END RESULTS

- **Fill media** was mostly a **mixture** of different materials (**peat, soil, sand, gravel**), varying in grain size, portion and composition.
- **Depths of SSF CWs** in Mediterranean countries varied mostly from **0.4 to 0.8 m**.
- The **bottom slope of beds** varied from **0-2%**.
- Hydraulic Retention Time (**HRT**) was usually chosen as between **3-4 days for SSF**.
- **Mechanical pre-treatment** in most cases are done in a **primary sedimentation basin**, a **septic tank**, an **Imhoff tank** and **screenbars**.
- High or Low Density Polyethylene (**HDPE, LDPE**), Reinforced Poli-Olefine (**POL**), **concrete blocks**, **bentonite, compacted soil** and/or **clay**, are the **materials** used to **seal the bottom of the wetland cells** in Mediterranean countries; among which the **HDPE** is the **most frequently used** one with a minimum thickness of **2 mm**. .

END RESULTS

- Despite favourable conditions for wastewater treatment by helophytes, **the elimination of Helminth eggs by CW systems**, there have been **limited studies** under the arid climate of Mediterranean countries.

- Some of the CWs furnished an effluent corresponding to **B category** according to the **WHO Guidelines** (WHO, 1989), which could be reused for **irrigation of cereal crops, fodder, pasture** and **trees**.

- **While designing CWs**, **water losses through evaporation and/or evapotranspiration** was found to be **one of the fundamental criteria** in the design and proportioning.

➢ Sizing of the CWs in the Mediterranean Region:

To design a CW system is **NOT** as **SIMPLE** as it is presented elsewhere: “**they are simple, easy to operate**…”.

The **designer** should be an **experienced person** **both in theory & practice** of this topic.

The **design of CWs** should be approached in a **multidimensional way** and **several disciplines** should **collaborate together**.

Otherwise, the systems designed by **inexperienced persons**, can **look at first pretty** and **functioning**.

However, after a while, the **system may collapse** (overloading, clogging, overflow, odour problems, etc.) & the **desired effluent criteria** will not be met.

Moreover, where the CW technology is progressing these **negative impacts** can result in **prejudices** among the **stakeholders** on this extensive treatment technology.

Further development of CWs in the Region might be affected.

A STRATEGETIC PLANNING PROCESS

1) Analyze the existing situation related to the CW application

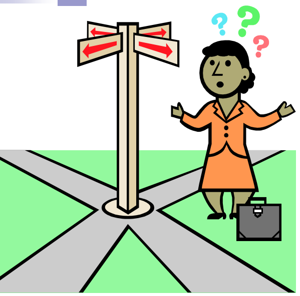
2) Establish a consensus for a plan among the stakeholders

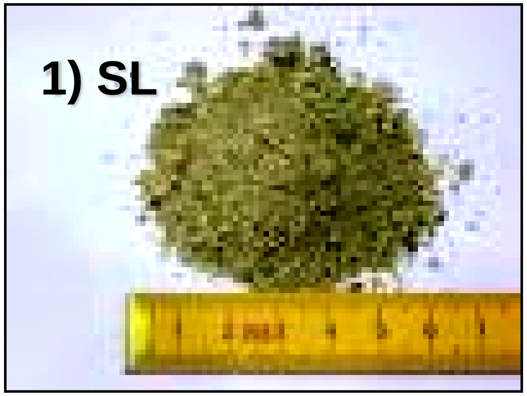
3) Design and size the units of the CW facility properly

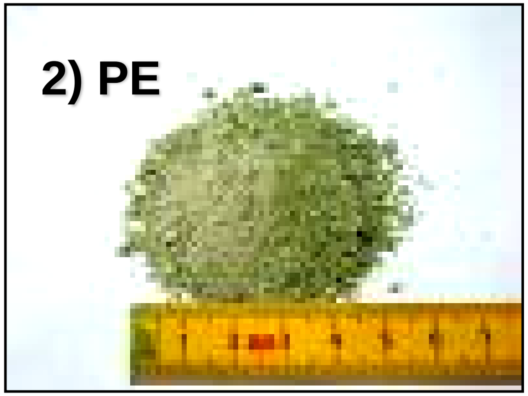
4) Evaluate the developed solutions, decide for the best solution and implement the concept

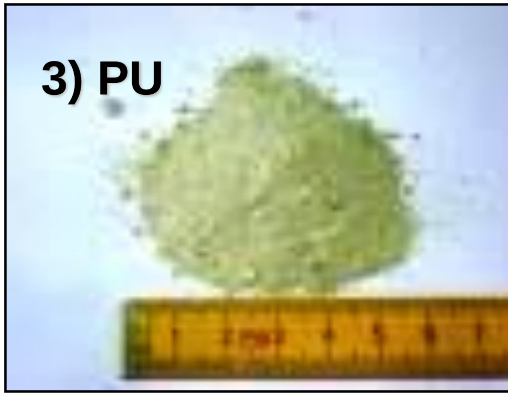
5) Prepare an O/M programme to be followed for the CW system

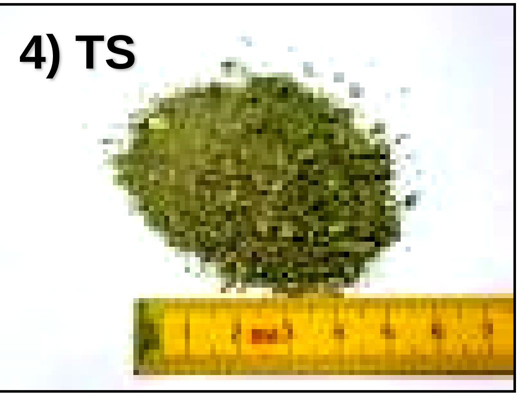
6) Determine a monitoring programme to evaluate the performance of the CW system to be operated.

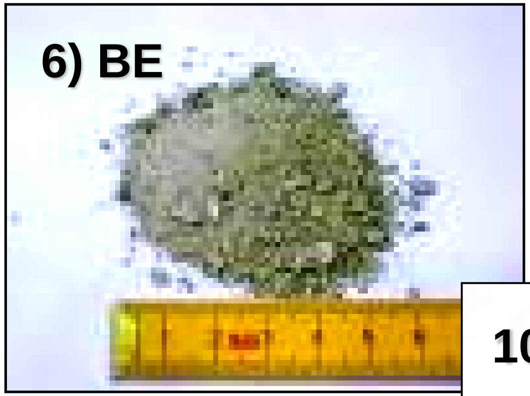


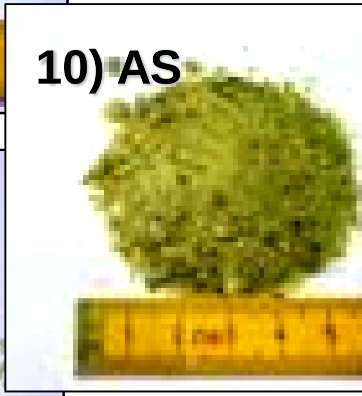


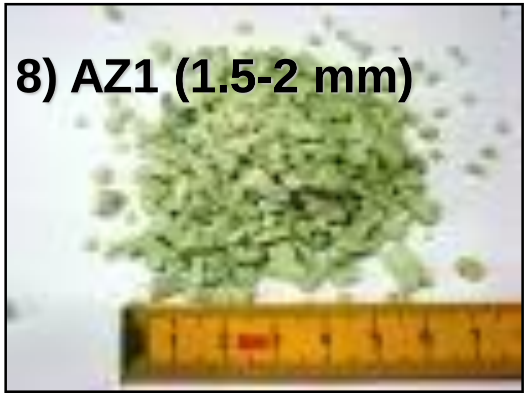












SUBSTRATES FROM TURKEY (1-5) & FROM AUSTRIA (6-10)


Vorsicht
schwebende
Last
weilen
RIAN SAND
(AS)
ZEOLITE 2
(AZ-2)
ZEOLITE 1
(AZ-1)
(FE)
(BE)