Design Details for Constructed Wetlands

based on the example of the

WASTEWATER TREATMENT PLANT
for the
HOSPITAL FOR LUNG DISEASES
JASENOVO, MUNICIPALITY OF CASKA

FINANCED BY:
AUSTRIAN DEVELOPMENT COOPERATION

BENEFICIARIES AND EMPLOYER:
MACEDONIAN MINISTRY OF TRANSPORT
MUNICIPALITY OF CASKA
HOSPITAL for LUNG DISEASES JASENOVO

presented by
Gerhard Knoll
Posch&Partners Consulting Engineers
www.pap.co.at

for the
Ecological Sanitation Online Course

UNESCO-IHE
Institute for Water Education
Beneficiary: TBC Hospital Jasenovo, Municipality of Caska, Republic of Macedonia

Background:

Financing Agency: ADA (Austrian Development Agency)

Beneficiary: TBC Hospital Jasenovo, Municipality of Caska, Republic of Macedonia

Engineer: Posch&Partners Consulting Engineers (Project Management, Design, Tendering and Construction Supervision)

Contractor: DGT “ZIKOL”, Construction Company, Strumica, Republic of Macedonia

Follow-up project after improvement measures on water supply system were realised (2003-2005)

Project period: February – October 2006
Existing Waste Water (WW) Situation

Collection of Hospital WW by an old brick sewer in a not maintained and non-operating septic tank

- Uncontrolled discharge of tank effluents
- Uncontrolled discharge of laundry effluents
Why opting for a Constructed Wetland?

Jasenovo Hospital is situated in remote area (on-site treatment necessary) with sufficient land availability

 Territory was found to be suitable for gravity driven operation (sufficient height difference) – no power supply necessary

Waste water treatment in proximity to Hospital: CW offer nice appearance in recreational surrounding

CW are low on O&M measures – operation by trained hospital staff possible
Design Parameters

Design based on Austrian standard ÖNORM B2505 (standard for use, design, construction and operation of CW)

Key points:

- Standard valid for CW for communal sewage < 500 PE
- Standard covers horizontal sub-surface flow (HSSF) and vertical sub-surface flow (VSSF) CW
- Avoidance of toxic substances and stormwater → separate sewer system preferred
- Nominal hydraulic load: 150 l/(PE*d)
- Nominal pollutant load: 60 g BOD$_5$/(PE*d)
- Mechanical pre-treatment by screen and sedimentation tanks essential → avoidance of clogging of CW filter bed
# Pollution Load Calculation

## POLLUTION LOAD JASENOVO HOSPITAL

<table>
<thead>
<tr>
<th>Consumer Groups</th>
<th>Unit</th>
<th>Max. future Units</th>
<th>Specific Pollution Load [g BOD5/d]</th>
<th>Total future Pollution Load [g BOD5/d]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary Patients</td>
<td>Bed</td>
<td>120</td>
<td>60</td>
<td>7200</td>
</tr>
<tr>
<td>Ambulant Patients</td>
<td>Patient</td>
<td>12</td>
<td>15</td>
<td>180</td>
</tr>
<tr>
<td>Workers and Management (from 07:00am to 14:00pm)</td>
<td>Capita</td>
<td>48</td>
<td>20</td>
<td>960</td>
</tr>
<tr>
<td>Medical Personnel (permanent)</td>
<td>Capita</td>
<td>12</td>
<td>60</td>
<td>720</td>
</tr>
<tr>
<td>Kitchen</td>
<td>meals</td>
<td>264</td>
<td>16</td>
<td>4277</td>
</tr>
<tr>
<td>Laundry</td>
<td>kg</td>
<td>60</td>
<td>12</td>
<td>720</td>
</tr>
<tr>
<td>Domestic consumption (5 houses)</td>
<td>Capita</td>
<td>15</td>
<td>60</td>
<td>900</td>
</tr>
<tr>
<td>(In future houses will be used for private patients)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>14957 g BOD5/d</strong></td>
</tr>
</tbody>
</table>

*Design population equivalents (PE) (=total BOD5 load / 60g BOD5/PE)*

**249**
Main Plant Components

Pre-treatment:

- Screen with free spacing = 20 mm (manually cleaned)
- 3-chamber septic tank \( V_1 : V_2 : V_3 = 2 : 1 : 1 \)

\[
V_{\text{tot}} = 0.25 \, [m^3/PE] \times 50 \, [PE] + 0.15 \, [m^3/PE] \times (249 - 50) \, [PE]
= 42 \, m^3
\]

i.e. 0.25 m³ for first 50 PE and 0.15 m³ for every PE above 50

Constructed Wetland:

- Type: VSSF CW \( \rightarrow 4 \, m^2/PE \)
- Area required \( = 249 \, [PE] \times (40/60) \, [g \, BOD_5/d] \times 4 \, [m^2/PE] \)
\[= 665 \, m^2\]
\[= 2 \, \text{beds with 333} \, m^2\]

Max. recommended single bed size
400 m²

Reduction of \( BOD_5/(PE \times d) \) to 40 after mech. pre-treatment allowed
Plant Overview

SEWER INFLOW

MECHANICAL TREATMENT

DISTRIBUTION SYSTEM

LOADING PIPE

LOADING MANHOLES

OVERFLOW

DiPipes 1

CW 1

1/1

1/2

DiPipes 2

CW 2

2/1

2/2

DISCHARGE MANHOLE

CREEK

22.50

12.50
Details Pre-Treatment

Screening and 3-Chamber Tank
Concrete C25/30
Vertical Section

INFLOW
STEEL BAR RAKE
FREE SPACING 20mm

GATE (STEEL/WOOD)
SLOPE 0.5%
DN200

91.20
89.75
89.10
87.50

91.00
WOODEN PLANKS
T-PIECES
DN200

1.25
2.25

TO FLOW DISTRIBUTION SYSTEM

CONCRETE 30cm
MASS CONCRETE 10cm
GRAVEL 20cm
Details Pre-Treatment

Screening and 3-Chamber Tank
Concrete C25/30
Ground View

NOTE:
Crosswise position of T-pieces
Parallel chambers for cleaning – gates for closing
Construction of Pre-Treatment Unit

Concreting base slab 3-chamber tank

Reinforcement & shuttering 3-chamber tank
Realised Details of Pre-Treatment Unit

- T-structure in 3-chamber tank
- Inflow gate
- Inflow and steel rake
Flow distribution & Hydraulic Valves

Loading of CW beds with WW shall be intermittently in order to facilitate oxygen diffusion

Loading interval between 3 and 6 hours; max. duration / loading: 15 min.

Loading by pumps or by hydraulic systems (gravimetrically driven)

Hydraulic systems require 1,50m height difference to the CW beds as a minimum

Hydraulic systems may require further division of CW beds → flow distribution necessary

Chosen for Jasenovo:
- Use of hydraulic valves
- Two separate distrib. systems per CW bed → 4 separate systems in total
- Flow distribution by another hydraulic valve and pipe system
Details Flow Distribution System
Vertical Section

DISTRIBUTION MANHOLES
PREFABRICATED CONCRETE
WITH HYDRAULIC VALVE 250 l/min
AND FLOW DISTRIBUTION UNIT

LOADING MANHOLES
CONCRETE C25 / 30
WITH HYDRAULIC VALVES 500 l/min

INFLOW FROM 3-CHAMBER TANK

WOODEN PLANKS

TO CW BEDS

MASS CONCRETE 10cm
GRAVEL 20cm
Details Flow Distribution System

Ground View
Flow Distribution in Practice

Distribution Manholes
for HV 250
for flow distrib. syst.

Pipe Inlet Detail

Flow distribution system
Construction of Loading Manholes

Loading manholes with tarred coating

Hydraulic valve 500 l/min
Up: floating on inflow water to pre-set max. level
Down: weight of flown in water

Flexible, chemically resistant sleeve

Installation of 4 HV 500

Loading manholes with tarred paper
CW Beds (VSSF Beds)

Main filter layer shall have a permeability coefficient of $k = 10^{-4} \cdot 10^{-3} \text{ m/s}$ and be of high mechanical stability (sand, gravel)

Avoid unnecessary compaction of layers, also during construction → no vehicles on gravel or sand!

Beds need to have impermeable base and side walls:
- either clay layer ($k \leq 10^{-7} \text{ m/s}$), 30 cm thick, compacted in 2 layers to 95% Proctor density ($\rho_{Pr}$)
- or adequate sealing foil made of plastic

Detail Cross Section CW Beds
Excavation and Sealing of CW Beds

Excavated CW beds

Compaction of sealing clay layer (2 x 15 cm)

Compaction of clay in corners

Control of compaction by Proctor test
Layers and Drainage of CW Beds

Cover layer (gravel 8/16) 10cm
Main layer (sand/gr 1/4) 60cm
Transm. layer (gravel 4/8) 10cm

Clay sealing layer and perforated drainage pipes (solid, non-perforated pipes put over them at embankments, see also slide 24)
**WW distribution on CW beds**

WW needs to be equally distributed on CW beds → minimum one discharge point per 2m² of bed surface

Pressure pipes with singular discharge points or perforated (with boreholes) distribution pipes (either laid on bed surface or elevated on suitable blocks)

Minimum pipe diameter DN 40, boreholes 8mm

Pipes shall be UV resistant and have a small specific coefficient of linear expansion [mm/(m x °C)]

Stainless steel bolts can be used for fixing spigot socket joints of distribution pipes

Distribution pipes shall foresee flushing access and drain-off automatically (avoid freezing)

Distance between two parallel pipes shall be limited to 1m

High temperature stabilized Polypropylene-Copolymer (HT-PPCO) pipes DN 50, elevated on concrete blocks, were chosen
WW Distribution on CW Beds in Practice

Drilling boreholes 8mm in distribution pipes

Main feeding pipe to CW beds

Pipe clamps on concrete blocks

Bolts for spigot socket joints

Alternatively longitudinally cut PE-pipes can be used
Alignment of concrete blocks

Taper piece for flushing

Water outflow of distribution pipe

Laid distribution system

In case of higher flow rates a baffle shall be used
Further Plant Components and Details

Drainage:
- CW base shall be sloped (0.5 – 1 %)
- For better drainage, drainage pipes DN ≥ 80 can be laid in max. distance of 3m; for aeration and flushing pipes shall be extended above bed surface (see slide 20)

Wetland Plants:
- Plants shall have deep roots and reeds have shown best suitability
- Planting is best during growing season (spring to summer) but possible year-round
- Locally available seedlings (not grown up plants) shall be used
- Approximately 5 plants / m² shall be planted
- In Jasenovo 75% Phragmites Australis and 25% Typhia Latifolia were planted (however in autumn!)

Surface run-off:
- Avoid inflow of surface run-off of surrounding area (e.g by ditches, etc.); sediments (especially recently after construction) might contribute to clogging of the CW beds

Discharge Manhole:
Percolated, treated WW shall be collected in a discharge manhole for:
- Sampling and water quality control
- Weed control in CW beds by raising water levels in CW beds
Planting of Wetland Plants

Seedlings of Typhia Latifolia

Planting in main layer (not in cover layer)

Planting in autumn

Phragmites Australies and Typhia Latifolia
Discharge System

Water level regulation in CW beds by turning bends in discharge manhole up and down

**NOTE:** Lower water level only very slowly (some cm / d) in order to avoid compaction of filter layers
Final Overview and Costs

Total costs*:
Supply of Materials: 15,200 Euro
Construction Works: 76,700 Euro
(average salary of skilled worker in MK: approx. 300 Euro / months)
* incl 190m new sewer line
Problems encountered in June 2007

Overview plant growth

Plant density partially not satisfying → re-planting

3-chamber tank not emptied

Unsecured joints loosened
Thank you!

For further inquiries contact:
Mr. Gerhard Knoll
knoll@pap.co.at
Posch&Partners
Consulting Engineers
www.pap.co.at