A MULTISTAGE CONSTRUCTED WETLAND FOR WASTEWATER TREATMENT OF SMALL RURAL AGGLOMERATION IN TUNISIA

Ahmed GHRABI,
Latifa BOUSSELMI,
CERTE, Tunisia

Fabio MASI
IRIDRA Italy

Martin REGELSBERGER
AEE-Intec, Austria

INTRODUCTION

All the cities in Tunisia, with population > 5 000 inhabitants, are equipped by wastewater treatment plants.

40% of Tunisian population lives in small village or isolated habitat with an access to drinking water for almost of them (~ 94%).

83% of this population stay in poor sanitation services and their wastewaters was discharged directly without treatment.

- Only 3.2% of the rural populations have a sewage system, and 13.5% have a sanitary pit or septic tank.

- For these reasons, the Tunisian government is now interested by the development of sanitation in rural and small villages, where the sanitation represents a serious risk for environmental and human health.

- The technologies needed must be robust, simple and low-tech as possible, and can deliver a high quality of treated wastewater.

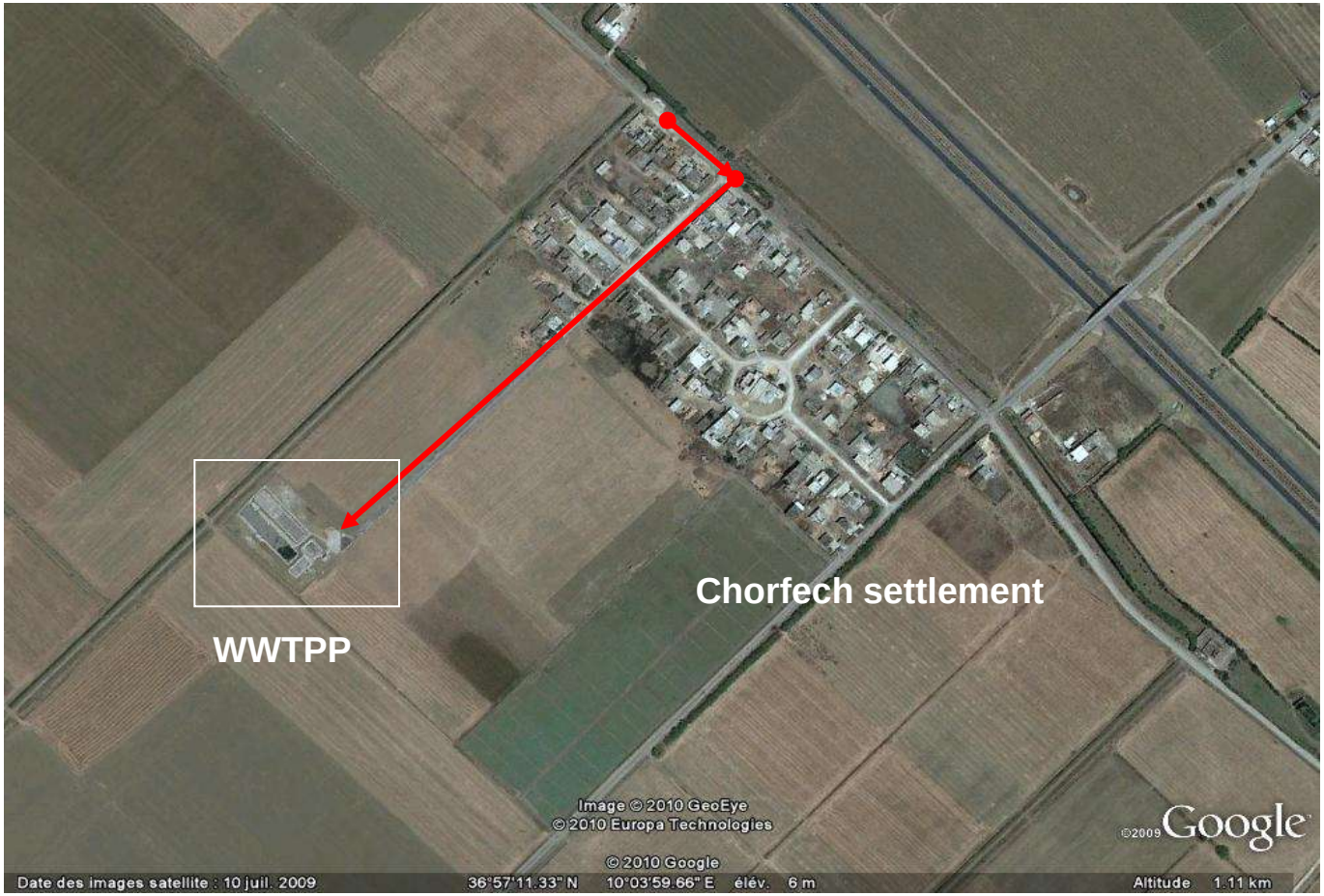
Objective of study

- This study presents the contribution of the research to solve the problem and to identify adapted wastewater treatment technology for the small settlements.

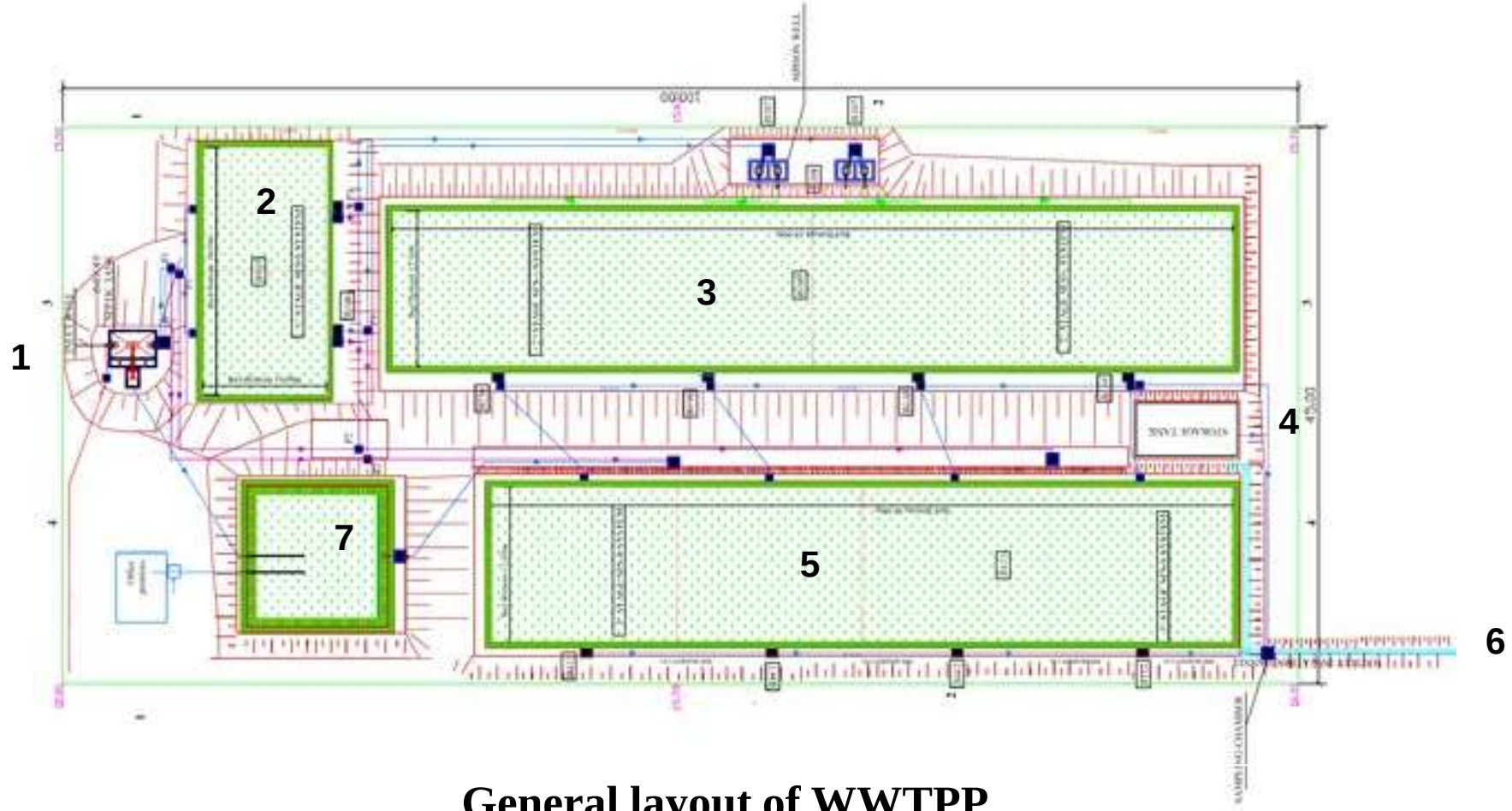
- The main objective is to implement a WWTPP, based in low cost technology adapted to the rural area in Tunisia; and at the same time solves the problem of uncontrolled wastewater discharged without treatment and allow the reuse.

Material and methods

- Chorfech is a rural settlement located at 24 Km in the NW of Tunis (350 inhabitants live in about 50 houses).



(36°57’11,33” N, 10°03’59,66” E)



General layout of WWTPP

1: Imhoff Tank;
2: 1st stage HF-CW;
3: 2nd stage VF-CW;
4: Reservoir of treated wastewater;
5: 3rd stage HF-CW;
6: Wastewater treated discharged in drainage channel;
7: Sludge Composting bed CW.

Pre-treatment Unit - Imhoff tank

- Reduce the solids in the inflow and to minimize the risk of clogging of the filter bed;
  - **Volume of the tank: 20 m³**
  - R**etention time is about 1 days.**

The Imhoff tank is connected by gravity to the 1st stage HFCW

sludge composting bed

- The sludge settling in the Imhoff Tank has to be removed from time to time 2 times per year) and transferred to the sludge composting bed.

1st stage HF-CW

- The HF-CW systems consist of 2 basins containing inert material (gravel) with selected sizes.

- The bottom and the walls of the basins are correctly waterproofed using synthetic membranes ‘’a sandwich of a thinner (HDPE) membrane with two layers of geotextile’’

Basins are planted by *Phragmites australis* (4 plants /m²).

2nd stage VF-CW

The 2nd stage VF-CW systems consist of 4 parallel basins.

• The wastewater is applied through a distribution system on the whole surface area.

• For the alternate feeding of the VF-CW there is siphons.

Feeding valve

The 3rd stage HF-CW

The 3rd stage HF-CW systems consist of 4 parallel basins.
The technical Specification of the HF-CW is same that the 1st stage.

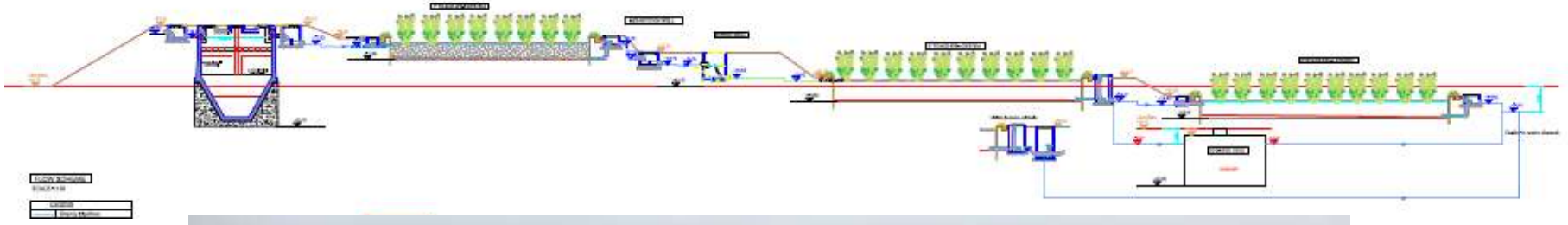
Profile of WWTPP

Imhoff Tank

1st stage HF-CW

2nd stage VF-CW

3rd stage HF-CW



Technical specification and characteristics of the WWTPP

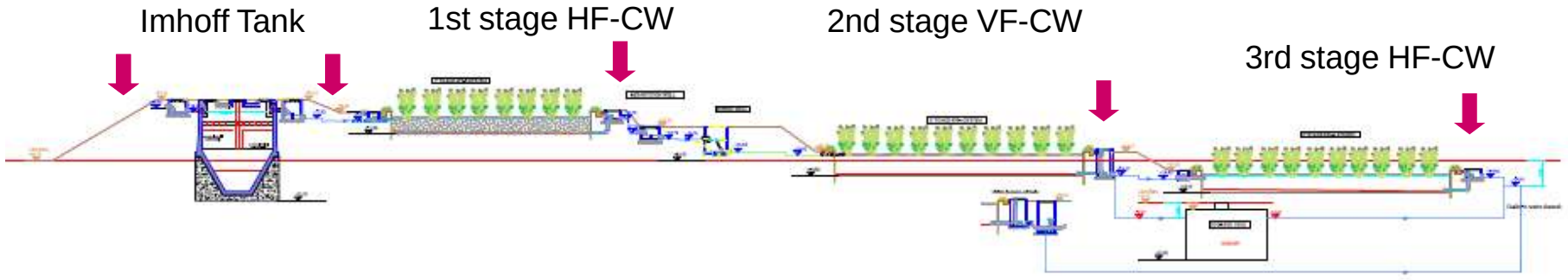
	Unit	1st stage Horizontal Flow Constructed Wetland	2nd stage Vertical Flow Constructed Wetland	3rd stage Horizontal Flow Constructed Wetland	Sludge Treatment Constructed Wetland
Total bottom surface	[m²]	200	850	750	100
Bottom length	[m]	10	12.5	12.5	10
Bottom width	[m]	20	68	60	10
Average medium height	[m]	0.8		0.8	
Inlet medium height	[m]	0.75		0.74	
Outlet medium height	[m]	0.85		0.86	
Bank slope	[ ]	90	90	90	45
Medium porosity (gravel 5-10 mm)		0.35		0.35	
Average water level	[m]	0.7		0.7	
Bottom slope	%	1	0.5	1	0
Filling material height (VF-CW)	[m]		0.95		
composed by (from bottom to top)					
Gravel 40-70 mm	[m]		0.15		
Gravel 5-10 mm	[m]		0.1		
Coarse Sand 0.02-0.1 mm	[m]		0.5		
Gravel 5-10 mm	[m]		0.2		
Drainage layer height (Gravel 20/40mm)	[m]				0.2
Filter layer height (Gravel 3/8mm)	[m]				0.3
Top filter layer height (Coarse Sand 0.3/0.5mm)	[m]				0.05

Monitoring of WWTPP

The WWTPP was monitored weekly between May and July 2010.

Physical chemical and microbiological analyses were performed:

- pH, COD, BOD, TSS, PO_4, Nitrogen.
- *E. coli* and *Enterococcus*.



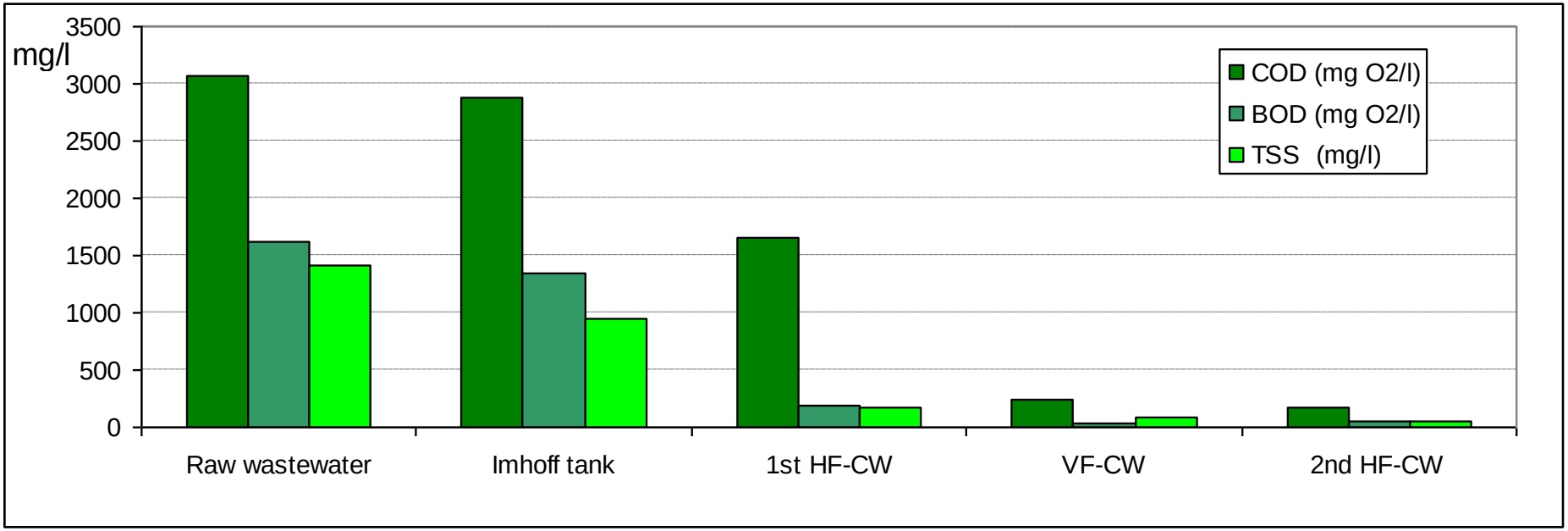
Results and Discussion

- Flow : 17 m^3/d.

- Load applied to CW system : 12.75 g BOD/m^2.d.

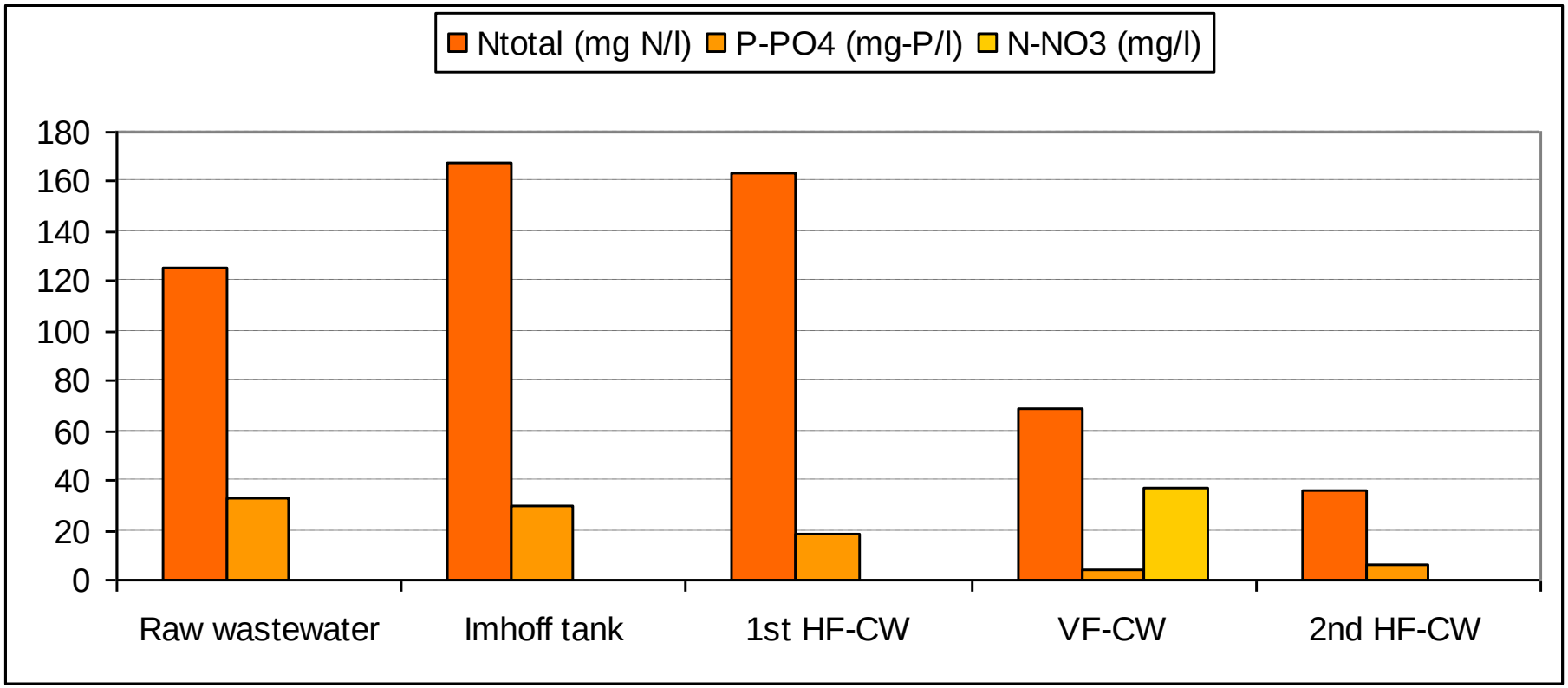
	COD (mg O2/l)	BOD (mg O2/l)	TSS (mg/l)
Raw wastewater	3072	1620	1407
Imhoff tank	2876	1350	956
1st HF-CW	1647	197	174
VF-CW	234	26	86
2nd HF-CW	167	45	53
Removal (%)	**94.6**	**97.2**	**96.2**

Removal of COD, BOD and TSS



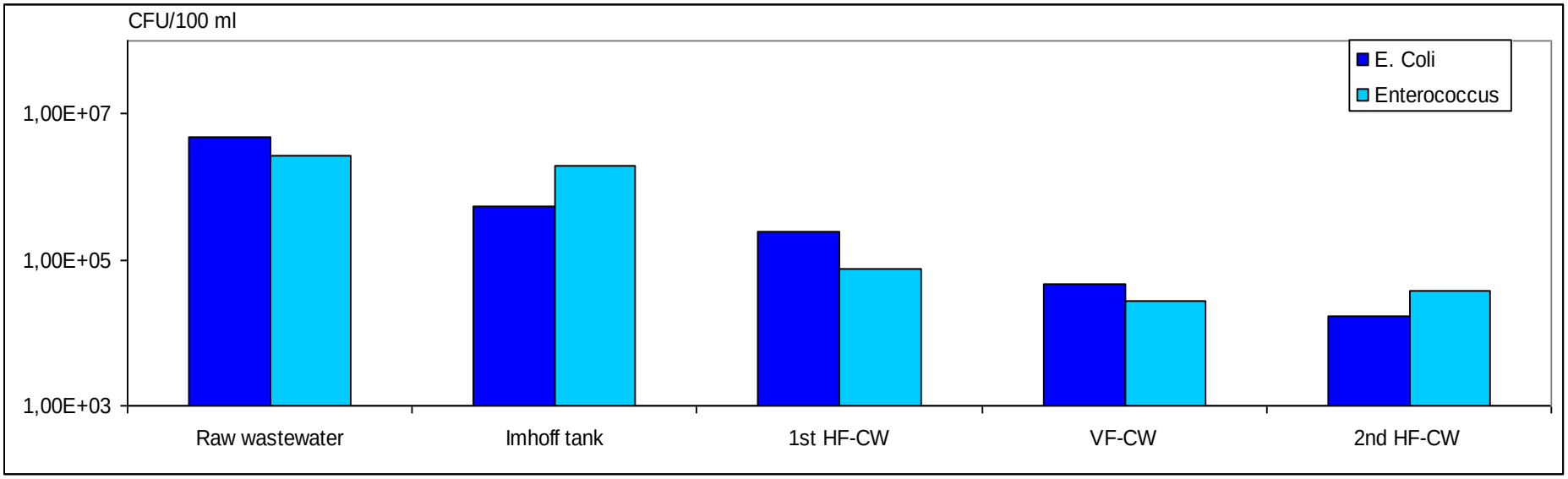
Removal (%)	COD	BOD	TSS
Imhoff tank	6,41	16,67	32,05
1st HF-CW	42,72	85,39	81,78
VF-CW	85,79	86,48	50,24
2nd HF-CW	28,51	(-)68,75	38,65
All the system	**94.6**	**97.2**	**96.2**

Removal of Ntotal, P-PO4 and N-NO3



	Ntotal (mg N/l)	P-PO4 (mg-P/l)	N-NO3 (mg/l)
Raw wastewater	125	33	0,37
Imhoff tank	167,7	29,5	0,5
1st HF-CW	163,85	18,2	0,5
VF-CW	69,3	4,2	36,8
2nd HF-CW	35,8	5,9	0,48

Removal of E. coli and Enterococcus



	E. Coli (UFC/100 mL)	Enterococcus (UFC/100 mL)
Raw wastewater	$4.69\ 10^{6}$	$2.65\ 10^{6}$
Imhoff tank	$5.36\ 10^{5}$	$1.91\ 10^{6}$
1st HF-CW	$2.39\ 10^{5}$	$7.47\ 10^{4}$
VF-CW	$4.53\ 10^{4}$	$2.77\ 10^{4}$
2nd HF-CW	$1.68\ 10^{4}$	$3.84\ 10^{4}$
Removal (Log unit)	**2.5**	**1.84**

Quality of treated wastewater / Discharge / Reuse

	COD (mg O2/l)	BOD (mg O2/l)	TSS (mg/l)	N-NH4 (mg/l)	N-NO3 (mg/l)	E. Coli (UFC/100 mL)
Raw wastewater	3072	1620	1407	120	0.37	$4.69\ 10^6$
Imhoff tank	2876	1350	956	70.1	0.5	$5.36\ 10^5$
1st stage HF-CW	1647	197	174	64	0.5	$2.39\ 10^5$
2nd stage VF-CW	234	26	86	60.4	36.8	$4.53\ 10^4$
3rd Stage HF-CW	167	45	53	32.2	0.48	$1.68\ 10^4$
NT 106.03 for reuse	90	30	30			
NT 106.02 for discharge	90	30	30	1 (N-NH4 and Organic)	50	2000 FC

- There is no limitation for the nitrogen in the case of reuse.

- If there is no reuse, the outlet quality for treated wastewater to be discharged into the aquatic environment must be satisfied NT 106.02

- The global removal is acceptable but insufficient compared to the norms authorizing the discharge of treated wastewater in the receiving water and reuse.

We need to improve the performance of WWTPP.

Conclusions

- The main task of the WWTPP of Chorfech is to implement a low cost technology adapted to the rural area.
- The preliminary results show the feasibility of the system. The WWTPP seems given the most powerful combination coupling the horizontal and vertical submerged flow constructed wetland after Imhof tank.
- The removal rates performed by the WWTPP of Chorfech during the monitored period have been respectively :
  - 97.12% for TSS,
  - 94.56%, for COD
  - 97.22% for BOD5,
  - 71.39% for total nitrogen,
  - 82.15% for total phosphorus.
- The removal of the E. coli and Enterococcus by the whole system was ranged from 1.8 to 2.5 log units.
- After improvement and stabilization of the performance, the system will be recommended to the authorities for wide application in in Tunisia.

Acknowledgments

The WWTPP was developed and erected in the project “Sustainable Concepts Towards a Zero Outflow Municipality (Zer0-M) mainly funded by the European Union in the frame of the Euro-Mediterranean Regional Programme for Local Water Management and co-funded with national funds.

www.zero-m.org

Thank you for your Attention

	N*	min	Average	max	Standard deviation	Removal (%) Each stage	Removal (%) All system	Standards NT.106.02 (a)	Standards NT.106.03 (b)
Flow (m^3/d)	6	14.41	17.00	21.60	2.69				
pH									
Raw wastewater	3	5.51	6.03	6.41	0.46				
Imhoff tank	6	5.71	5.95	6.23	0.24				
1st HF-CW	5	6.67	6.83	7.15	0.19				
VF-CW	4	7.33	7.62	7.88	0.29			6.5 - 8.5	6.5 - 8.5
2nd HF-CW	8	7.08	7.58	8.50	0.50				
TSS (mg/l)									
Raw wastewater	5	1015	1851	3016	750				
Imhoff tank	8	156	679	1580	523	63.3			
1st HF-CW	8	75	174	285	91	74.4			
VF-CW	7	20	86	356	121	50.6		30	30[(c)]
2nd HF-CW	10	19	53	130	40	38.4	**97.1**		
COD (mg O2/l)									
Raw wastewater	5	2300	3072	5040	1112				
Imhoff tank	8	2150	2876	5052	941	6.4			
1st HF-CW	8	384	1647	5204	1586	42.7			
VF-CW	6	102	234	410	123	85.8		90	90[(c)]
2nd HF-CW	10	124	167	214	30	28.6	**94.6**		
BOD (mg O2/l)									
Raw wastewater	3	1000	1620	2300	652				
Imhoff tank	4	120	1350	2900	1392	16.7			
1st HF-CW	4	25	197	600	271	85.4			
VF-CW	3	20	26	35	8	86.8		30	30[(c)]
2nd HF-CW	4	40	45	50	6	(-)73.1**	**97.2**		
Ntotal (mg N/l)									
Raw wastewater	3	50	125	256	113				
Imhoff tank	5	4	70	264	110	44.0			
1st HF-CW	5	9	65	128	51	7.1		NO_3 : 50	No
VF-CW	3	28	69	98	37	(-)6.2**		NO_2 : 0.5	limitation
2nd HF-CW	7	13	36	90	30	47.8	**71.2**	Org.+NH_4: 1	
P-PO4 (mg P/l)									
Raw wastewater	5	30.23	33.35	35.12	2.15				
Imhoff tank	5	24.60	29.51	34.09	3.40	11.51			
1st HF-CW	5	16.50	18.28	21.80	2.07	38.08			No
VF-CW	6	0.50	4.22	14.57	5.65	76.91		0.1	limitation
2nd HF-CW	7	0.80	5.95	11.11	4.55	(-)40.99**	**82.2**		
E. Coli (log FU/100 ml))						**log removal**			
Raw wastewater	5	6.45	6.67	7.08	6.64				
Imhoff tank	8	6.20	5.73	7.08	6.52	0.94		FC: 3.30/100ml	
1st HF-CW	8	5.32	5.38	7.48	7.04	0.35		FS: 3.00/100ml	
VF-CW	7	4	4.66	5.26	4.76	0.72		N <1/l[(d)]	N < 1 / l[(d)]
2nd HF-CW	9	2.48	4.23	5.18	4.74	0.43	**2.45**		