Università degli Studi della Basilicata
Scuola di Ingegneria

The ferti-irrigation plant for the green belt of Marrakech constraints and futures development

International workshop
WASTE WATER REUSE: from research to knowledge and technology transfer in the Mediterranean region

The FAO-Italy project (GCP/RAB013/ITA) on the use of treated waste water in forestry and agroforestry systems of arid zones.

Potenza, Italy, 29 - 30 April 2013

Global context of the project

The Italian ministry of foreign Affairs funded FAO project GCP/RAB/013/ITA:

The objective is to establish four demonstration sites to show the advantage of reuse of treated waste water in forestry and Agroforestry (In Algeria, Tunisia , Egypt and Morocco)

The specific objective in the context of Morocco

The installation of ferti-irrigation plant by treated wastewater for the preservation and rehabilitation of the green belt of Marrakech city (peri-urbain agroforestery)

With collaboration with the university of Basilicata, Italy

Moroccan Partners collaborating in the project

Haut Commissariat des Eaux et Forêts

Régie Autonome de Distribution d’Eau et D’eléctricité (RADEEMA)

University Cadi Ayyad Marrakech

Principals realized steps in the project Progress in Morocco

First visit of the representative of FAO to differents potentiel partners to be involved in the project

Organisation by FAO of a Workshop in November 2012 in Marrakech to discuss the fAO project with partners and stakeholders

Visit (2 months) of Moroccan student-engineer from Marrakech to the University of Basilicata

Main recommandations of Novembre 2012 workshop in Marrakech

Better Implementation of the RADEEMA

Visit of General representative of FAO in Morocco.

Elaboration of a draft of Protocol agreement between the Moroccan partners

Role of the university Cadi Ayyad

- The aim of the project is to Study the feasibility of using treated wastewater by a specific treatment (preserve nutrients) and to reuse it in ferti irrigation for Agro-forestry;

- The participation of UCAM : Technical studies, contribution to the design, installation and monitoring of fertigation system;

- In the following, we will present the design project and the study of availability of raw water for ferti-irrigation;

III

Selection of the study site

Figure 2 : The study site (H.C.E.F.L.C.D)

The ferti-irrigation plant for the green belt of Marrakech constraints and futures development

Technical studies

Done by the Univ. Cadi Ayyad in collaboration with the UniV. Basilicata

- Collection of climate data for the studied site
- Agronomic Study and assessment of crop needs;
- Design of irrigation system and WWTP for ferti-irrigation in Marrakech with collaboration with Univ. Basilicata

Collection of data for studies

I	Physical and chemical characteristics of WWTP of Marrakech;
II	Climate analysis for the green belt in Marrakech
III	Determining of the study site;
IV	Soil analysis of the study site;

Marrakech Aerobic WWTP with sludge digestion and methane production for energy co-generation

I

Physical and chemical characteristics of WWTP of Marrakech

Table 1 : Current load input to WWTP of Marrakesh (SDAL)

Parameters	Nominal Values	average Inputs	Maximum values
Daily flow (m^3/d)	**90 720**	**110.374**	**178.100**
Peak hourly flow (m^3/h)	7 704	7.395	13.075
BOD5 concentration (mg/l)	**640**	**480**	**638**
BOD load (kg/d)	58 100	53.197	76.305
SS concentration (mg/l)	584	426	766
SS load (kg/d)	53 000	46.936	91.614

I

Physical and chemical characteristics of WWTP of Marrakech

Table 1 : Current load input to WWTP of Marrakesh (SDAL)

Parameters	Nominal Values	average Inputs	Maximum values
Daily flow (m^3/d)	**90 720**	**110.374**	**178.100**
Peak hourly flow (m^3/h)	7 704	7.395	13.075
BOD5 concentration (mg/l)	**640**	**480**	**638**
BOD load (kg/d)	58 100	53.197	76.305
SS concentration (mg/l)	584	426	766
SS load (kg/d)	53 000	46.936	91.614

I

Physical and chemical characteristics of WWTP of Marrakech

Table 2 : The physicochemical characteristics of wastewater in Marrakesh WWTP

Parameters	input STEP	Primary Treatment	Secondary Treatment	Tertiary Traitment	
pH	7,89	7,59	8,05	8,20	
Conductivity	1964,43	1790,71	1641,71	1623,71	
SS (mg/l)	346,86	82,67	11,15	53,79	
DBO_5 (mg/l)	**550**	**325**	**20,4**	**6**	98%
DCO(mg/l)	**825,29**	**488,43**	**34,87**	**29,93**	96%
NTK (mg/l)	83,76	65,71	15,96	15,26	83% NTK
NO_3 (mg/l)	0,00	0,83	5,61	6,13	
NO_2 (mg/l)	0,00	0,00	0,65	0,58	
PT (mg/l)	10,35	8,09	4,96	5,36	
PO4 (mg/l)	6,83	6,16	4,68	5,05	

Source of climate data parameters:

- These are series ies of daily observed data (for the period 1998 - 2011) (Saada):
- Average temperature, maximum temperature, minimum temperature,
- Cumulative monthly and annual rainfall,
- Wind speeds,
- Relative humidity,

II

Climate data analysis

Table 3 : Temperature, rainfall and evapo-transpiration in Marrakesh (1998 – 2011)

	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec
M	19,05	20,49	23,57	25,78	29,21	33,80	37,50	36,64	32,25	27,97	22,64	19,79
m	4,04	5,90	8,15	10,54	13,35	16,54	18,83	18,97	16,68	13,54	8,27	5,40
P (mm)	22,87	28,8	20,86	19,61	14,97	2,85	1,33	4,88	6,82	23,31	33,13	18,5
ETo (mm/month)	60,00	77,10	110,70	132,90	150,60	176,40	189,00	176,70	143,70	105,90	72,60	54,30

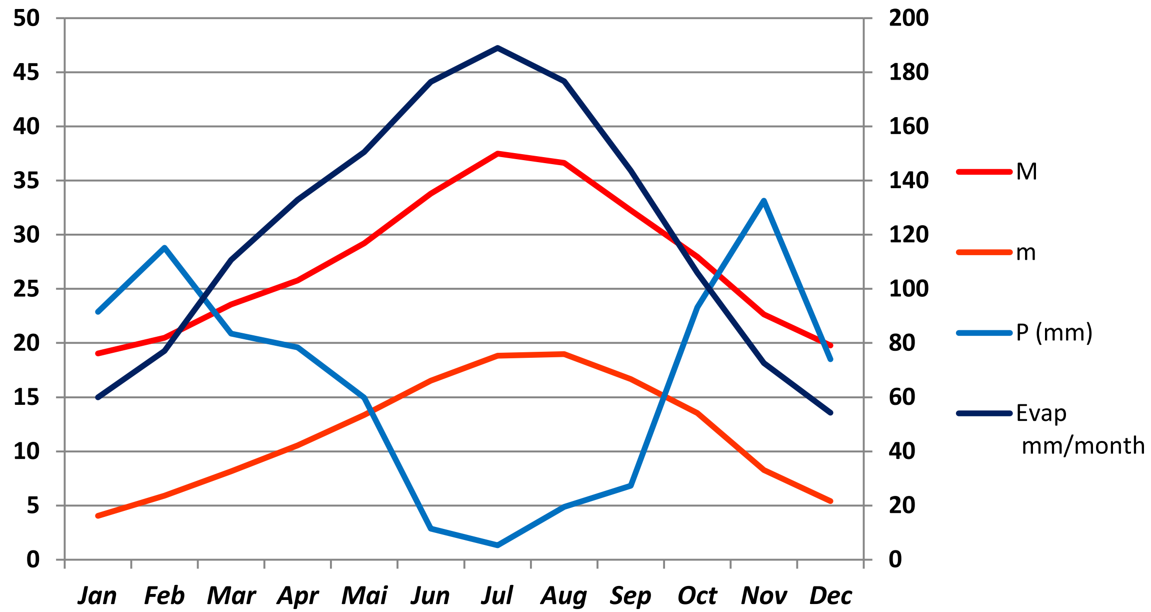


Figure1 : Graphical representation of T, P et ETo (1998-2011)

IV

Soil analysis of the study site

Table 4 : Soil texture analysis

Parameter	**Unit**	**Analysis results**			
Texture		**$S._1$**	**$S._2$**	**$S._3$**	**$S._4$**
Clay	%	7,39	7,82	7,60	9,10
Fine Silt	%	8,80	28,07	31,54	36,92
Coarse silt	%	18,38	23,23	17,21	28,19
Coarse sand	%	37,30	23,30	24,88	14,70
Fine sand	%	28,14	17,58	18,77	11,09

The soil texture is Sandy-loam, it contains approximately 60-65% of sand;

IV

Soil analysis of the study site

Table 5 : Physicochemical characteristics of Soil

Parameter	Unit	Analysis results			
pH		**7,49**	**8,49**	**8,77**	**7,61**
Humidity	%	0,07	0,16	0,13	0,19
Conductivity	µs/cm	165,00	366,00	446,00	284,00
C. organic	%	**0,75**	**0,63**	**0,88**	**1,89**
Organic matter	%	**1,30**	**1,08**	**1,52**	**3,25**
NTK	%	0,09	0,10	0,11	0,42
Ratio C/N		**8,12**	**6,43**	**7,86**	**4,53**
Total Phosphorus	mg/g	3,38	0,75	0,59	1,92
Assimilable phosphorus	mg/g	0,08	0,03	0,02	0,05

The pH is relatively high with a low organic matter content (1-3%). This soil contains on average 0.18% of total nitrogen, C/N ratio is less than 10 indicates that the soil is mineralized with low organic matter reserves .

Agronomic study and evaluation of crops needs

1 Evapotranspiration

$$ETc = Kc * ET_0$$

- **ETc** : Crop evapotranspiration under standard conditions [mm d^{-1}],
- **Kc**: Crop coefficient [dimensionless],
- **ET_0**: Reference crop evapotranspiration [mm d^{-1}],

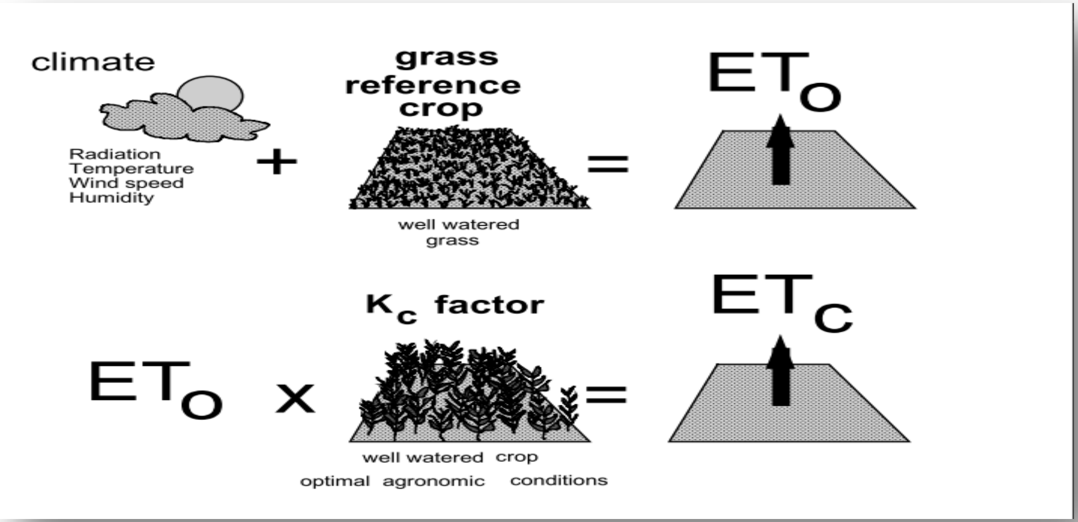


Figure 4 : Evapotraspiration process

Agronomic study and evaluation of corps needs

2 Net irrigation requierment : NIR

$$NIR = ETc - Peff$$

- **NIR:** Net irrigation requirements;
- **ETc:** Crops evapotranspiration**;**
- **Peff:** Effective rainfall;

3 Gross irrigation requierment : GIR

$$GIR = NIR/eff$$

- **GIR:** Gross irrigation requirements;
- **NIR:** Net irrigation requirements;
- **eff**: Efficiency of the irrigation system;

Agronomic study and evaluation of crops needs

4 Crops water requirement

Table 6 : Crops water requirement

	Sept	Oct	Nov	Déc	Jan	Fèv	Mars	Avril	Mai	Juin	Juil	Aout
ET0 (mm)	143,70	105,90	72,60	54,30	60,00	77,10	110,70	132,90	150,60	176,40	189,00	176,70
Rainfall	6,82	23,31	33,13	18,50	22,87	28,80	20,86	19,61	14,97	2,85	1,33	4,88
Olivier												
Kc	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70	0,70
ETc	100,59	74,13	50,82	38,01	42,00	53,97	77,49	93,03	105,42	123,48	132,30	123,69
Water requirement mm/month	93,77	50,82	17,69	19,51	19,13	25,17	56,63	73,42	90,45	120,63	130,97	118,81
Date Palms												
Kc	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90	0,90
ETc	129,33	95,31	65,34	48,87	54,00	69,39	99,63	119,61	135,54	158,76	170,10	159,03
Water requirement mm/month	122,51	72,00	32,21	30,37	31,13	40,59	78,77	100,00	120,57	155,91	168,77	154,15
Tamarix spp												
Kc	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80	0,80
ETc	114,96	84,72	58,08	43,44	48,00	61,68	88,56	106,32	120,48	141,12	151,20	141,36
Water requirement mm/month	108,14	61,41	24,95	24,94	25,13	32,88	67,70	86,71	105,51	138,27	149,87	136,48

- Olive tree water requirement : **817 mm/y**
- Date palms water requirement : **1106 mm/y**
- Tamarix spp water requirement : **962mm /y**

Design of irrigation system

1 Description of irrigation system:

- The perimeter of 10 hectares, composed of five section (2.5 hectares) extensible to 10ha

- A storage tank, the water will be injected to the distribution network via a pumping station;

- The system is designed to irrigate alternatively different sections;

Design of irrigation system

2 Irrigation network

The irrigation pilot in Marrakesh is designed taking into account the flowing parameters:

- Plantations density 10m x 10 m (**100** pt / ha);
- Amount of water supply per day and per hectare :

20 m^3/day/ ha;

- Number of drippers for each plant: **2 < Drippers < 4 ;**
- Distance between each dripper : **0.7 at 1.4 m;**
- Flow rate in dripper **: 6** at **16** liter/hour;
- Length of watering time: **4** at **2** h / day;

Design of the irrigation system

2 Irrigation network

- Simplified scheme of irrigation system

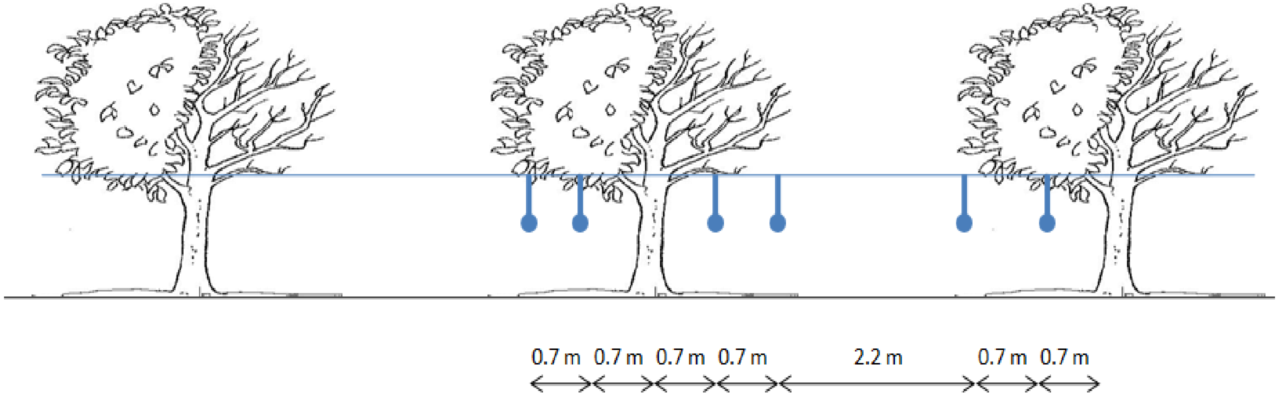


Figure 5: Simplified scheme of irrigation system

- Scheme of irrigation system in AUTOCAD

Conception and design of irrigation system

2 Irrigation network

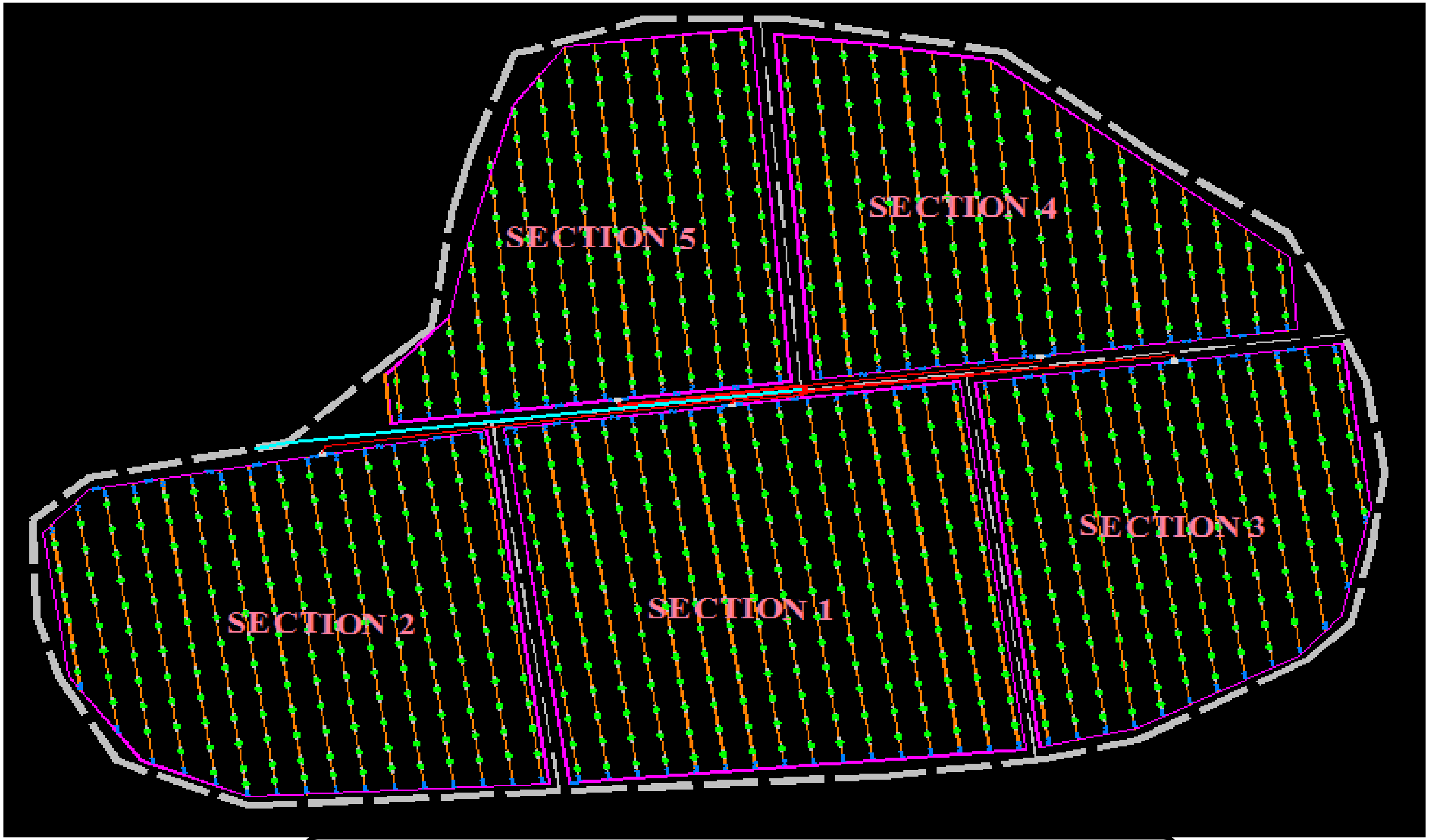


Figure 6 : irrigation network

Design of irrigation system

3 Caracteristic sof storge tank

The utility of this storage tank is to satisfy the water demand is generally higher than the availability of resources during the peak periods ensuring regular operation of the system during this period;

❑Characteristics of the storage tank:

Optimizing the volume of storage tank we proposed a basin of 200 m^3 that will ensure the total need of 10 ha, playing on the irrigation schedule alternatively with two plot 1,5ha each day.

- **Daily requirements during the peak months (for 10 ha): 200 m^3 /day.**
- **Irrigated area every day: 3 ha (two plots of 1.5 ha)**
- **Number of days of autonomy irrigation during the peak months 3 days.**
- **Tank volume: 200 m^3.**

Conception and design of WWTP

1 Modified scheme for WWTP- Marrakesh

- **The WWTP plant designed to ensure the needs of water for 10 ha,**
- **according to the climatic and agronomic studies the plant must provide a total volume water at last 200m^3/day;**
- **The WWTP will be installed in a simple way that will allow to collect water easily (primary and secondary treatment); as shown in the following scheme (fig.7);**

Conception and design of WWTP

1 Modified scheme for WWTP- Marrakesh

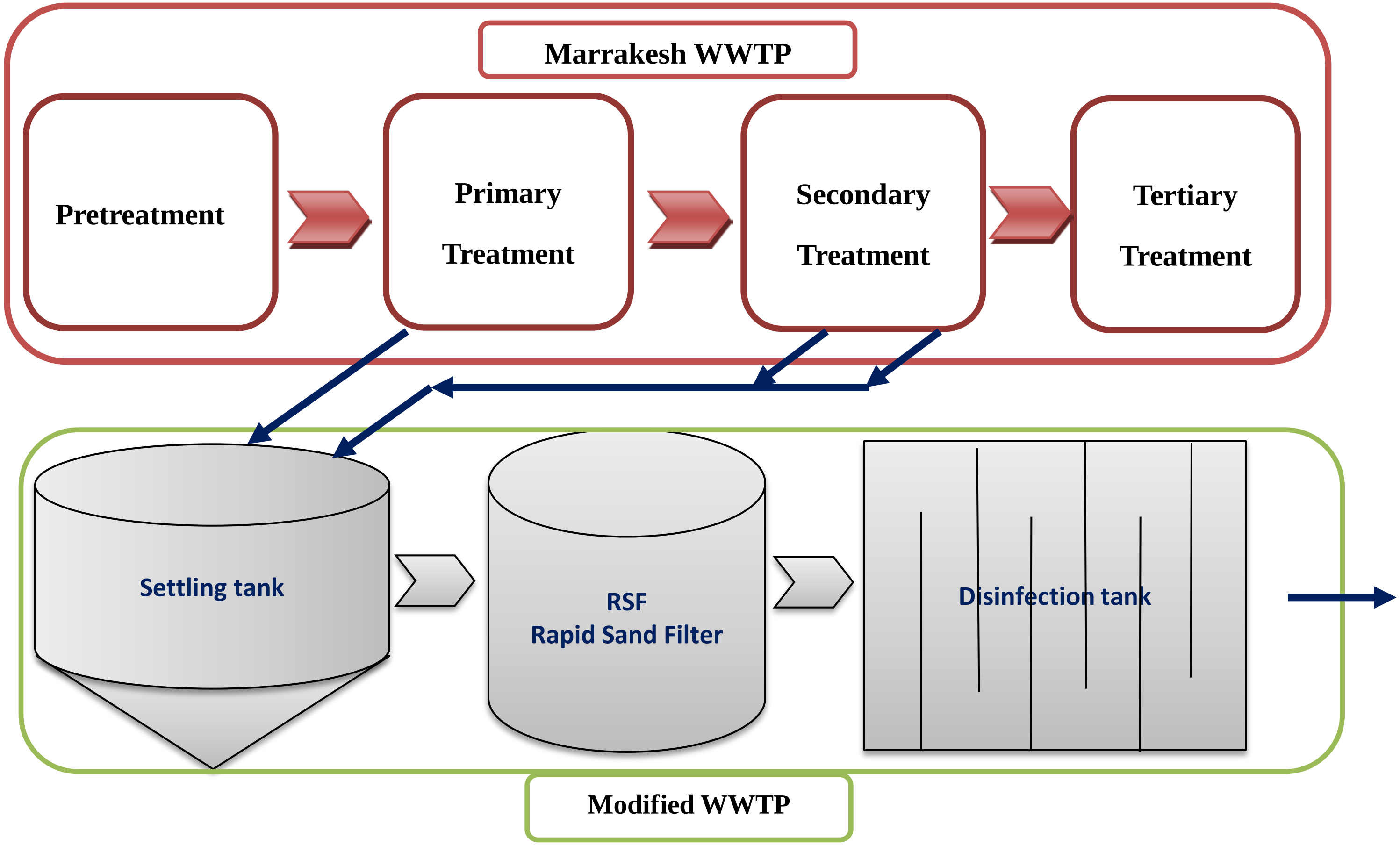


Figure 7 : Modified scheme for WWTP in Marrakesh

Conception and design of WWTP

1-a Settling tank

Table 7 : Characteristics of Sedimentation tank

Raw water flow per day is 200 m^3 Detention period is 2h			
Volume of tank = Flow x Detention period			
volume of tank	25 m^3		
Assume depth of thank	2 m		
Surface area	12,5 m^2		
Volume of cylinder :	Volume of cylinder = π x (Radius)² x h = π.r².h		
The Radius			
Radius	**2,0**	Diameter	**4,0**

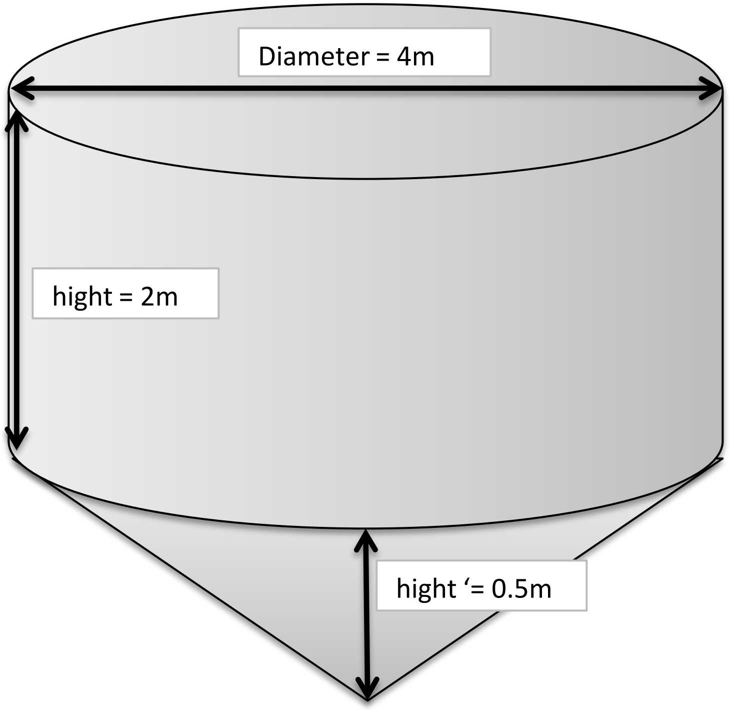


Figure 8 :Simplified scheme of settling tank

Conception and design of WWTP

1-b Rapid sand filter

Table 8: Characteristics of rapid sand filter

Design parameters :

Design a rapid sand filter to treat a flow	Qm	200	m^3/day
Allowing filtered water for backwashing:	Q_Bw	0,5%	
Time used for backwashing per day	T_Bw	0,25	hours
Assume the rate of filtration		10	m/h
Number of Filters		1	

Result of dimensioning :

Total filtered Water		m^3/h	12,76
Area of filter		m^2	1,28
The high and diameter of RSF			
Hypothesis	**High of filter**	h (m)	1,50
Diameter	**D = A/h**	D(m)	0,85

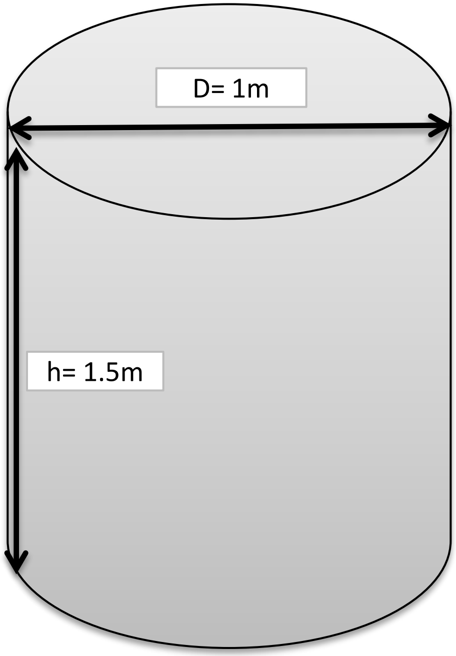


Figure 9 : Simplified scheme of RSF

Conception and design of WWTP

1-c Desinfection tank

Table 9 : Characteristics of disinfection tank

Volume of disinfection tank

$$Vdis = Qm * RT$$

Vdis	Volume of disinfection tank (m^3)	
Qm	Average flow (m^3/h)	12,5
RT	Retention Time (h)	0,5
A.N	**Vdis (m3)**	6,25

The disinfection tank volume = 6,25 m3

Assumed depth of disinfection tank 2m including 0.5 m of safety

	Hypothesis			
Hp	h =	1,5		
Length	L =	2,5		
Area of unit (m^2)	**S = V/h**		**Area of Disinfectant tank**	4,2
length (**m**)			**Width of Disinfectant tank**	2,02

Conception and design of WWTP

1-c Desinfection tank

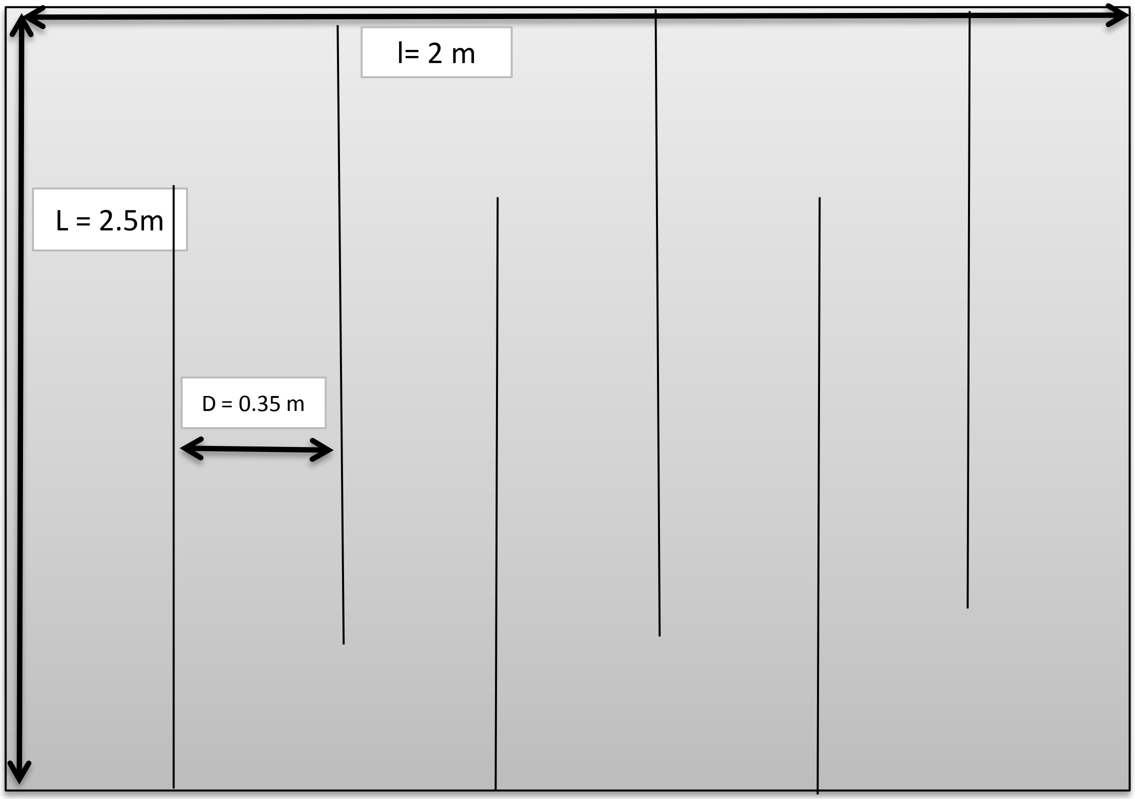


Figure 10 : Simplified scheme of disinfection tank

Economic study basing on this conception

Estimated costs

Taking into account the low budget available, , we will start with only an experimental field of 2.5 ha. An extension to 10 ha could come after ;

The estimated cost of the irrigation system integrates all the steps of the future network, namely, excavation, conduit installation, the location of the pumping stations, equipment, installation of the storage tank;

The calculation of the estimated cost suppose that all plants will be constructed in situ.

The cost of the adduction realization is also estimated but without

Estimated costs

❑Estimed costs of the project :

	Total T.T.C (10ha)
Irrigation system	52 120,80 DH
Adduction system	11 500,00 Dhs
WWT system	445 000,00 Dhs
Total	508 620,80 Dhs 63 577 ,6 Dollars

Constraints and futures development

- Technical contraints/ needs :

- Need of a detailed technical study , to be realised by Service provider company (request of RADEEMA).
- Need of geotechnical study about how to link the Marrakech WWTP to The pilot of ferti-irrigation site.
- Exploitation of the system

III Determinig of the study site

Figure 2 : The study site (H.C.E.F.L.C.D)

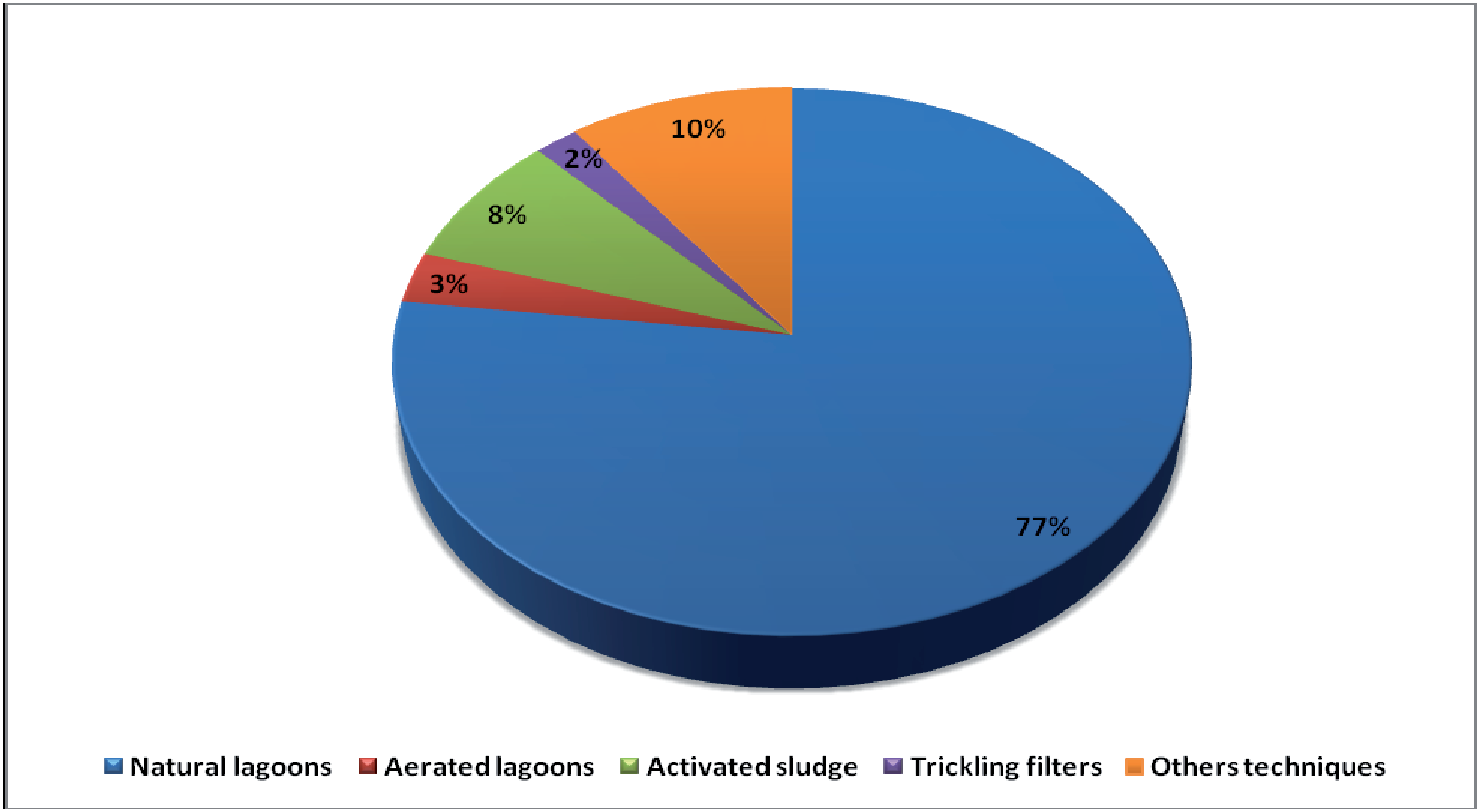
Constraints and futures development

- Institutional needs :
- Waiting for progress of the convention between all the implemented institutions?
- Who is doing what? Responsabilities of each partner?
- Scientific perspectives : In waiting the pilot installation UCA will do experimentation on laboratory scale

Thank You

http://www.fao.org/forestry/tww/80069/en/

Distribution of different kind of wastewater treatment technologies existing in Morocco (Makhokh and Bourziza, 2011)



The Largest aerated lagoons in Morocco (Oujda City)

Wastewater treatment and reuse project of Benslimane City (El Haite, 2010)