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Wastewater in the Peri-Urban Area of Great Casablanca (Morocco): Status Quo, Treatment and Potential Reuse in Urban Agriculture

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Abstract

In the 21st century one of the major interests in the world is the access of a fast growing population to water resources in a sufficient quality and quantity. This situation gets more frequent and graver because of the hydrological consequences of climate change. In Morocco since several years, dry periods have occurred repeatedly and they became characteristic for the regional climate. Therefore the lack of water got a major problem. For the remediation of this situation, the reuse of wastewater is one of the priorities in the national sewage treatment plan of 2005 [2].

On the level of the metropolitan area of Grand Casablanca, water is a major challenge for the sustainable development because the region is characterised by an arid climate with only modest resources of water, which have an irregular occurrence in time and area and always a low quality. 98 % of the drinking water of this metropolis which sums up to over (170 million m³ per year has to be imported from other regions (Bouregreg in the North and Oum Er Rbia in the South) both with a distance of about 80 km).

The produced industrial and domestic wastewater is estimated with a total amount of 500,000 m³/d which are rejected into the sea without treatment. Only 60% of the wastewater is currently primarily treated by a grid at the El Hank station and subsequently emitted into the sea via a 3.6 km pipeline.

Since the year 2008, this situation has begun to change in the peri-urban area of Casablanca, because many wastewater treatment plants (WWTP) are currently under construction:

- The WWTP of the airport Mohammed V which is constructed by the national airport agency (ONDA). It will treat 4,000 m³/d of municipal wastewater and 1,500 m³/d of industrial wastewater in separate lines.

- The WWTP of the country town of Deroua which is constructed by the autonomous regional water and electricity distribution group (régie autonome de distribution d'eau et d'électricité de la Chaouia, RADEEC) for capacity 2,000 m³/d of municipal wastewater.

- The WWTP of the country town Mediouna which is constructed by the water and energy public private partnership of Casablanca (Lyonnaise des eaux de Casablanca, Lydec) to treat 4,000 m³/d of municipal wastewater. This plant is going to be the first Membrane Bioreactor System in Morocco.

Other WWTPs are planned by the Lydec at Tet Mellil/Sidi Hajjaj with 1,500 to 2,000 m³/d. In the year 2015-2020 there will be about 10,000 m³/d of treated municipal wastewater available in the Northeast peri-urban area of Grand Casablanca. These sums up to 3.5 million m³/year which could be used to irrigate 1,200 to 1,500 ha of agriculture. This reuse in agriculture will result in a less severe impact on the environment and will foster the economic development in the region.

Key words: Casablanca, Morocco, wastewater, treatment, reuse, Urban Agriculture

1- Introduction

Morocco is a country with strong population, economic and urban growth resulting in increased wastewater discharges. Therefore low cost solutions have to be found which take into account efficiency, environmental protection and public health.

Indeed, surveys and studies related to the field of sanitation and the environment which have been carried out in Morocco since the early 1990s, showed a considerable delay in sanitation including wastewater treatment which manifests by [1]:

- A backlog in basic infrastructure of sewerage systems;
- A national connection rate of around 70%;
- A low level of wastewater treatment (less than 10%) with a limited number of wastewater treatment plants (WWTPs) of which nearly half is out of operation.

To remedy this situation, the National Sanitation and Liquid Wastewater Treatment Plan (Plan National d'Assainissement Liquide et d'Épuration, PNALE) was developed [2] with the main objectives:

- Establishing sewage sanitation as a government priority;
- Achieve a national connection rate of 80 % in 2020 and 90% in 2030;
- Diminish the domestic pollution by 80 % in 2020 and 90 % in 2030;
- Treat and reuse or recover 100 % of the collected wastewater in 2030.

The city of Casablanca is not an exception to this critical situation in terms of sanitation, especially in terms of produced wastewater. A part of the treatment plant for digestion/sedimentation of the Mohammed V airport, which dates from 1953 and the pre-treatment station of El Hank, built in 1995, this city of more than 4.5 million people, Morocco's economic capital, has no real central wastewater treatment plant.

Thus, the urban development plan of the Grand Casablanca elaborated by the city planning agency (Agence Urbaine de Casablanca) in 2008 states that urban development in the city of the rank of a true international metropolis can not be considered without efficient and sustainable technical solutions to solve the various problems of basic urban services including sanitation. The solutions have to take into account the entire region and integrate the perspective of implementation of several WWTPs in the coastal and suburban area. This was proposed by Lydec in the global sanitation master plan developed at the beginning of the delegated water management in the Grand Casablanca area (PPP contract 1997-2027).

The purpose of this study is to establish an inventory of wastewater in selected urban centers in the peri-urban area of Casablanca which contains:

- Diagnostics of quantity and quality of wastewater.
- Treatment systems in construction.
- Opportunities for reuse of treated water for Urban Agriculture.

2 - Presentation of studied peri-urban centers and materials and analytical methods

2.1-Study peri-urban centres

The Grand Casablanca region is important for the economic and social development of Morocco. It is the location of a port responsible for 60% of the national trade, the most important industrial center (38%) and financial center (30%). With such activity, the city experienced a population growth, providing 39% of employment of the Moroccan workforce and is therefore a powerful magnet that attracts much of the rural exodus of the country. The city planning agency (Agence Urbaine) estimates that the population of the Wilaya of Grand Casablanca reaches more than 5 million habitants by 2027.

To reduce the pressure of urbanization on the city, various centers have been developed at the urban fringe to accommodate residential, commercial and industrial areas (Figure 1).

Three peri-urban centers have been the subject of research since 2003:

- The area of the airport Mohammed V / Nouaceur is located almost 30 km south-east of downtown Casablanca. It belongs to the municipality of Nouaceur (province Nouaceur) and includes:
 - A residential area with a population of about 8000 inhabitants [3].
 - The area of the Mohammed V airport which covers a total surface of 1295 ha and includes airport infrastructure (terminals, various buildings, military barracks....) and an industrial park (Aéropole) hosting approximately sixty companies (commerce, engineering, metal industries, food and pharmaceutical, electronic and electrical and special chemicals).

- The urban center of Deroua is located about 25 km southeast of Casablanca at the road which connects Casablanca and Marrakech. This center belongs administratively to the capital of the rural community of Deroua and is part of the circle of El Gara and the province of Settat. The population is approx. 25,000 inhabitants and dominant socio-economic activities are agriculture, commerce and some small industries manufacturing building materials.
- The urban center of Mediouna is located about 17 km southeast of downtown Casablanca. The center is a part of the province Mediouna which is the main agricultural area of Casablanca. The population sums up to 20,000 inhabitants and economic activities are dominated by agriculture, trade and industry with thirty small and medium companies (mechanics, metallurgy and building materials).

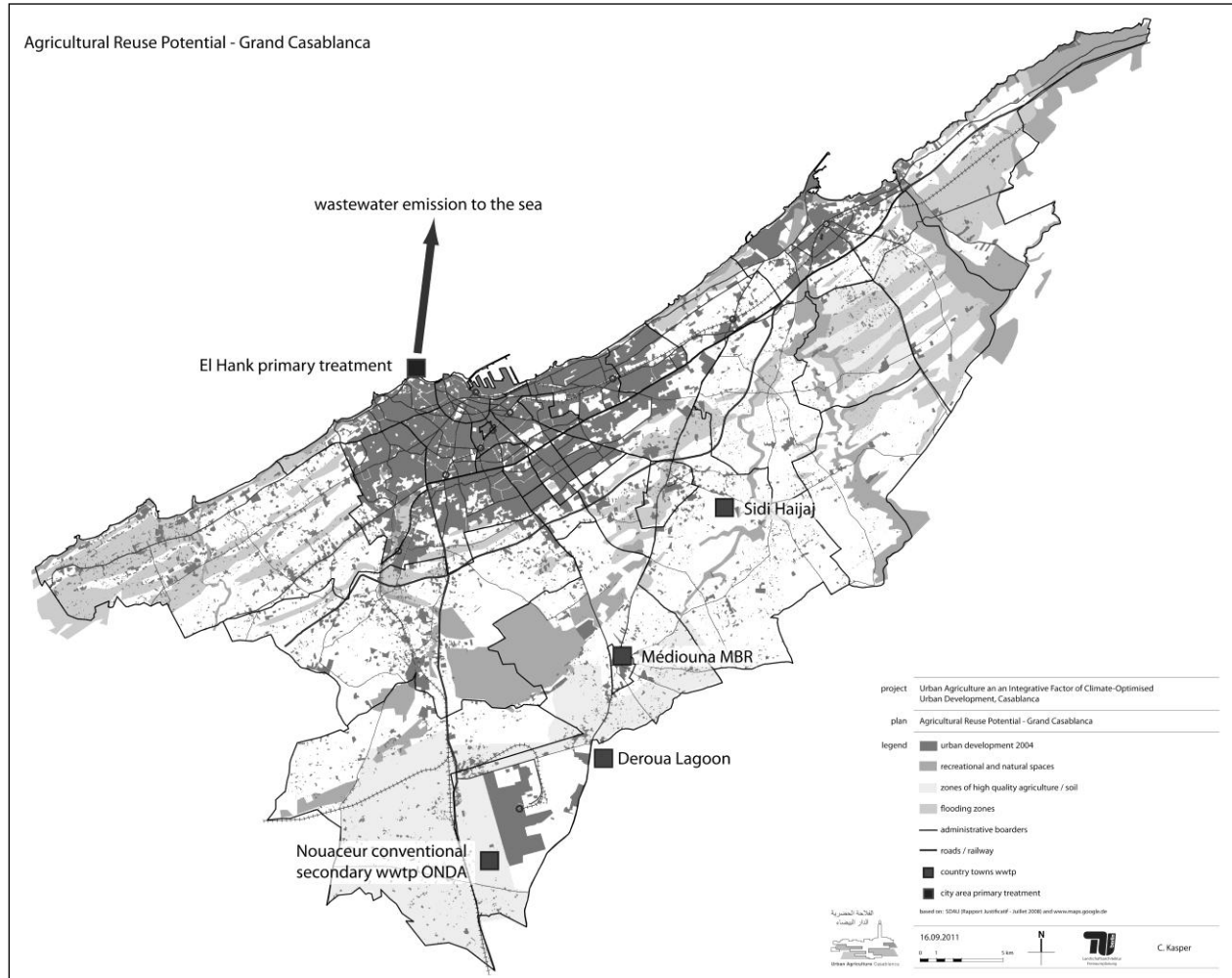


Figure 1: Location of study centers in the northeast of peri urban area of Casablanca.

Concerning the climate, the three peri-urban centers are subject to a Mediterranean type climate with a semi-arid oceanic influence marked by mild winters and dry summers. The average annual temperature varies between 13 and 23 °C and total annual precipitation recorded in recent years are 362 mm on average [4].

2.2-Methods and techniques of measurement and analysis used

The in situ measurement techniques used in this study are either appropriate measuring equipment: A Hanna pH meter type HI8014, a conductivity type and a multiparameter analyzer WTWLF90 type CONSORT C535 or the methods and analysis techniques involve experimental protocols of Afnor (1999) [5] and Rodier (1984) [6].

3 - Diagnosis of wastewater quality and opportunities for treatment and reuse

3.1-The area of the Mohammed V-Airport/Nouaceur

The Mohamed V airport in Casablanca is a centerpiece of the development of the region Nouaceur because of its socio-economic role related to traffic and industrial and commercial activities located at the Aeropole (Industrial Park). The wastewater generated by the platform is collected in a separated sewer system. The total volume of wastewater is the order of [7]:

- 4000 m³/d of domestic wastewater (DWW) from buildings and infrastructure of the airport terminals as well as military barracks and the city of air at the village of Nouaceur.
- 1500 m³ /d of industrial wastewater (IWW) generated by the Aeropole and the industrial area of Royal Air Maroc "RAM".

By the year 2016-2025, the ONDA will treat an average flow of DWW about 7200 m³/d and an average flow of IWW in the order of 1920 m³/d.

On the qualitative level, the studies that we conducted between 2002 and 2005 [8], the analytical results performed by the ONDA [9] and those obtained following other complementary studies we have initiated in 2009/2010 [7] have provided a comprehensive profile of the physical and chemical quality of the wastewater from different types of domestic and industrial activities as follows (Table I):

Table I: Profile of the overall quality of raw sewage from the airport Mohammed V-Nouaceur

	Domestic wastewater DWW	Industrial wastewater IWW(discharge from the Aeropole)
Temperature (°C)	18 - 24	19 - 27
pH-Value	6,3 – 6,8	6,1 – 6,4
BOD ₅ (mg/L)	530	1700
COD (mg/L)	914	3700
SS (mg/L)	584	614
Nitrogen TNK (mg/L)	50	66
TP (mg/L)	32	82

The reported COD/BDO₅ equals 1.72 and 2.17 for the DWW and for IWW between 2 and 3 which shows that the total wastewater in the area are biodegradable, and the nitrogen content TNK remains below 100 mg/L. However, the COD is quite high at the IWW as a result of large quantities of oxidisable materials generated by various industrial units of the Aeropole.

To this end, the ONDA launched in 2007, a project to build a new wastewater treatment plant consisting of a secondary treatment using the activated sludge process. This plant meets the needs of wastewater treatment of the entire area of the airport Mohamed V / Nouaceur until 2025. This station has two processing lines: one for DWW with the possibility of reuse of treated water and one for the IWW with a perspective of agricultural reuse of treated water (Figure 2 a and b). At the same time, ONDA has begun to encourage and push the companies of the Aeropole to treat their wastewater before discharging into the sewer system. Furthermore the experiences of advanced treatment of industrial wastewater with an option to reuse in agriculture are being implemented as pilot projects in the frame of the Urban Agriculture project in Casablanca. The Pilot Project consists of a tertiary treatment with an aerobic membrane bioreactor and a treatment of raw industrial wastewater in an anaerobic membrane bioreactor [10].

The ONDA conventional treatment plant will have an annual volume of treated water of about 1.8 million m³ in 2011/2012 which could irrigate an agricultural area between 450 and 800 ha on the basis of a reuse rate of 70% (30% can be lost by evaporation or due to leaks in pipelines, storage tanks etc) and according to the irrigation techniques used (traditional by gravity or modern drip irrigation). By 2025, the annual volume of treated water would be about 3.2 million m³ resulting in an irrigable area between 750 and 1500 ha.

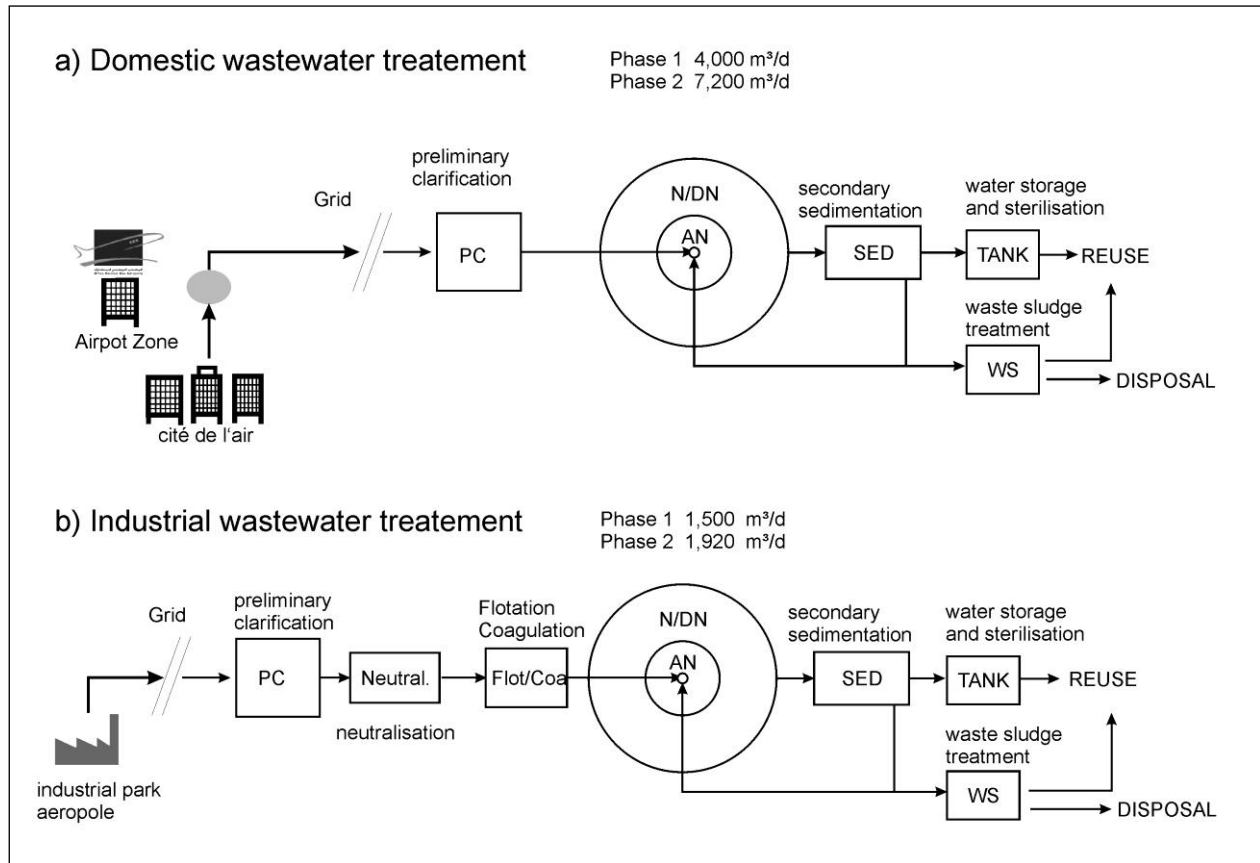


Figure 2: WWTP of the ONDA at the airport Mohammed V, (a) DWWTP, (b) IWWTP based on [9].

3.2-The town of Deroua

In this small urban center drinking water is supplied by the independent group of water and electricity in Chaouia (RADEEC). Wastewater is discharged directly into a sewer system consisting of septic tanks equipped with soakaways. Studies conducted in 2006 allowed us to estimate the overall volume of wastewater produced, which is approx. 700 m³/d based on a return rate of 80% of the water consumed [11]. This amount will increase to 1500 m³/d in 2010 and in 2015, to 2000 m³/d, when an increase of over 30% every five years is assumed.

The physical and chemical analysis of the wastewater (Table II) shows an essentially domestic origin as the average ratio COD/BOD₅ equals to 1.24 (less than 2.5). The nitrogen (TNK) content is high enough as well as the concentration of degradable organic matter as the BOD₅ exceeds 1300 mg/L.

Table II: Quality of raw sewage from the urban center of Deroua [11]

	Minimum	Maximum	Average
Temperature (°C)	14	29	21,6
pH-Value	5,39	7,73	6,48
Conductivity (µs/cm)	1650	4740	2965,8
SS (mg/L)	8,5	76	41,2
COD (mg/L)	615	1840	1354,9
BOD ₅ (mg/L)	138	1385	1089,2
Nitrogen TNK (mg/L)	30,4	123,28	75,3

Taking into account the quality of produced wastewater that shows great potential of biodegradability, natural lagoon system was chosen.

The annual volume of purified water by this station would be about 550,000 m³ at present and with a reuse rate of 70%, the irrigable area would reach about 130 ha in traditional mode and 150 ha in modern technology. By 2025, the annual volume of treated water would reach 630,000 m³ to irrigate about 250 ha traditionally and almost 300 ha in a modern way.

3.3-The urban center of Mediouna

The City of Mediouna, which is the subject of our research since 2008, is supplied with drinking water by the Lydec with a quantity of 2500 m³/d. The volume of generated wastewater is estimated according to our investigations [12] and that of Lydec [13] as 2000 m³/ d. This wastewater is collected in a separate sewer system but consists of a mixture of IWW and DWW. All produced wastewater is transported to the great collector Mediouna to be eventually discharged into the river Oued Hassar one of the key and scarce surface waters of Casablanca.

Table III: Quality of raw sewage from the urban center of Mediouna [10]

	Minimum	Maximum
Temperature (°C)	17	28
pH-Value	6,97	7,4
Conductivity (µs/cm)	2830	6500
Salinity (mg/L)	1300	2900
BOD ₅ (mg/L)	409,66	
COD (mg/L)	804,77	
Nitrogen TNK (mg/L)	41,66	98,8
TP (mg/L)	7,95	13,625

The report COD/BOD₅ calculated on the basis of these results is the order of 2 (1.96) confirming that the produced wastewater has a domestic character and is biodegradable. The processing system that Lydec chose to set up is an membrane bioreactor (BAM). The separation of the sludge is done by a membrane filtration chamber allowing higher biomass concentrations and adaptation of the sludge to the wastewater [14]. Therefore the effluent quality allows the irrigation of agriculture. The absence of total separation of suspended solids will allow an efficient reuse of the water by drip irrigation systems. The plant currently in construction will process about 2000 m³/d but is designed to treat up to 4000 m³/d by 2017.

In 2012, the volume of produced treated water will reach 730,000 m³ per year and therefore resulting in an irrigation potential, based on a reuse rate of 70%, of 170 ha by traditional and up to 340 ha by modern method. By 2025, the throughput would reach 7000 m³/d which would have an annual volume of treated water of approximately 2.5 million m³ of which 70% will irrigate up to 600 ha through traditional and about 1200 ha by modern technology.

4 - Conclusion

Casablanca is one of the largest cities in Africa that enjoy great urban development and socio-economic development where water is a major issue because of climatic and hydrological context that characterizes Morocco in general and the central region in particular . The latter is characterized by an arid climate and low water resources, erratic rainfalls and often poor quality of surface water. The drinking water supply, which amounts to 170 million m³ per year, is at 98% transferred from neighboring watersheds Bouregreg north and south Rbia Oum Er. The volume of wastewater from various domestic and industrial activities of this city is estimated to be approx. 500,000 m³/d, which are mostly discharged directly to sea.

At a time of climate change and development of various forms of adaptation around the world, the city of Casablanca is called, more than ever under the national plan of sewerage and treatment plants, to process and develop its wastewater. The suburban northeast of the city (Mediouna, and Nouaceur Deroua) offers opportunities to initiate such a process before it is generalized to other areas in the North (Mohammedia) and South West (Bouskoura and Dar Bouazza).

Approximately 10,000 m³/d are produced in this area suburban Northeast, which are divided broadly between the area of Nouaceur/Mohammed Airport (4000 m³/d), the localities of Mediouna (2500 m³/d) Deroua (1500 m³/d) and Sidi Hajjaj / Tet Mellil 1500 to 2000 m³/d).

Qualitatively, the wastewater produced in this area is mainly of domestic type but are also influenced by industrial discharge. At the platform of the airport Mohammed V / Nouaceur the IWW is collected and treated separately. Physical and chemical characteristics of its wastewater is generally characterized by a neutral to slightly acidic pH (6.5 to 7.2), an average BOD₅ of between 410 and 1700 mg/L, a average COD variable between 800 and 2200 mg/L (with a maximum of 3700 mg/L in the case of industrial wastewater from the airport) and a load of SS in the range of 600 mg/L on average.

The COD/BOD₅ ratio overall remains less than 2, or between 2 and 3 confirmed the biodegradability of wastewater produced. As a result, treatment plants in the study area which have been under development for the last three years are secondary biological activated sludge systems Nouaceur/Airport and Mediouna or in the case of Deroua a natural lagoon system. However, for the first time in Morocco, membrane filtration systems are implemented to improve the quality of treated wastewater for possible reuse in agriculture. The WWTP in Mediouna will be equipped with a membrane filtration for the separation of the sludge instead of a conventional sedimentation system.

In total these projects will purifie 10,000 m³/d of wastewater in the peri-urban areas in the northeast of Casablanca, which will result in an annual potential of about 2.7 million m³ purified water for irrigation. Based on a reuse rate of 70% with respecting Moroccan standards for irrigation (see appendix), between 850 ha (using conventional irrigation) and 1700 ha (using drip irrigation) could be irrigated. By 2025, the annual volume of treated water will be about 7 million m³ and the area irrigated will be between 1700 and 3300 ha depending on the efficiency of the irrigation system (table IV).

With this development, Casablanca would have a large productive green belt and will reduce the impact of climate change and meet a part of its alimentation from Urban Agriculture. Nevertheless the management of agricultural reuse of treated water including institutional coordination, irrigation infrastructure, training and support for farmers has to be implemented like it has been done in other parts of Morocco. This is an opportunity for Morocco to be one of the leading countries which demonstrate a sustainable management of its water resources as it has done in the past at their mobilization by the politics of dams.

Table IV: Potential for irrigation by treated wastewater in the northeast of peri urban area of Casablanca

Locality	Treated wastewater flow (m ³ /y)		Volume available for irrigation (70 % of Treated wastewater) (m ³ /y)		Irrigable area (in ha) by conventional irrigation		Irrigable area (in ha) by drip irrigation	
	2011/2012	2025	2011/2012	2025	2011/2012	2025	2011/2012	2025
Mediouna	730000	2500000	511000	175000	170	596	600	1200
Nouaceur/Aéroport Mohammed V	1825000	3285000	1277500	2299500	450	800	750	1500
Tet Mellil/Sidi Hajja	620500	730000	434350	511000	145	170	290	341
Deroua	550000	629625	385000	440737,5	130	150	250	300
Total					895	1717	1890	3341

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7- Appendix: Quality standards of waters designed for irrigation in Morocco

(Décret d'application de la loi 10-95 du 4 février 1998 (N° 2-97-787).

PARAMETRES	VALEURS LIMITES
PARAMETRES BACTERIOLOGIQUES	
Coliformes fécaux	100/500 mL*
Salmonelle	Absence dans 5l
Vibron Cholérétique	Absence dans 450 mL
PARAMETRES PARASITOLOGIQUES	
Parasites pathogènes	Absence
Œufs, Kystes de parasites	Absence
Laves d'Ankylostomides	Absence
Fluococercaires de Schistosoma hoematobium	Absence
PARAMETRES TOXIQUES (mg/L)	
Mercur Hg	0,001
Cadmium Cd	0,01
Arsenic As	0,1
Chrome total	0.1
Plomb Pb	5
Cuivre Cu	0.2
Zinc Zn	2
Sélénium Se	0,02
Fluor F	1
Cyanures CN	1
Phénols	3
Aluminium Al	5
Beryoum Be	0,1
Cobalt Co	0,05
Fer Fe	5
Lithium	2,5
Manganèse Mn	0,2
Molybdène Mo	0,01
Nickel Ni	0.2
Vanadium V	0,1
SALINITE	
Salinité totale mg/L**	7680
Conductivité électrique mS/cm à 25°C**	8.7
Si le SAR du sol=	
0-3	2
3-6	0,3
6-12	0,5
12-20	1,3
20-40	3
IONS TOXIQUES	
Sodium (Na)	
-Irrigation en surface (SAR***)	9
-Irrigation par aspersion (mg/L)	69
Chlorures (Cl)	
-Irrigation de surface (mg/L)	350
-Irrigation par aspersion (mg/L)	105
PARAMETRES	
VALEURS LIMITES	
EFFETS DIVERS	
Température	35°C
pH	6,5-8,6
Matière en suspension mg/L	
irrigation gravitaire	2000
Irrigation par aspersion et localisée	100
Bicarbonate (HCO3)	
Irrigation par aspersion (mg/L)	518
Sulfate mg/L	250

* 1 000 CF/100 ml pour les cultures consommées crues.

**A partir d'une conductivité électrique de 3µS/cm, une eau nécessite des restrictions sévères pour l'irrigation, mais des rendements de 50% du rendement potentiel peuvent être réalisés avec des eaux de 8,7µS/cm (cas du blé).

*** SAR = Sodium Absorption Ratio (taux d'absorption du sodium).