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WASTEWATER TREATMENT TECHNOLOGY ADAPTED TO SMALL AND MEDIUM COMMUNITY IN THE MEDITERRANEAN REGION

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PROJECT SUMMARY

Wastewater reuse represents a potentially important additional source of water in arid and semi-arid regions. The interest in the reuse of treated wastewater has increased significantly in southern part of morocco due to water deficit (over 260 millions m^3 per year) and increase demand for water supply.

The Municipality of Drarga is located in a semi-arid region near the coast in southwest Morocco. At the initiation of the project, the wastewater generated in the town was discharged untreated leading to the development of a large cesspool, where it percolated into the soil or evaporated. As part of the Water Resources Sustainability (WRS) project jointly funded by the United States Agency for International Development (USAID) and the Moroccan Ministry of the Environment, a wastewater treatment facility and water reuse system have been developed. At capacity, the wastewater treatment facility will serve an estimated 17,600 people in the Municipality of Drarga.

Based on the experience of Ben Sergao, irrigation with water that was treated by the infiltration-percolation system brings on the ground a quantity of nitrogen nitric that largely exceeds the needs for the agricultures and consequently generates nitrates in underground water. This is likely, in the long run, to considerably deteriorate the quality of water resources. This concern is even more significant in areas with sandy ground where the transfer of nitrogen towards the water sources is fast. To reduce nitrate loading to groundwater and controlling this pollution requires an ability to reduce the concentration of nitrate in the treated influent. In this respect WRS project added a denitrification basin to the treatments process in the Drarga plan by recalculating the effluent getting out from the sand filter, and used reed beds as a tertiary treatment. The objective of our study is to analyze the performance of the treatment process in terms of organic pollution reduction and nitrogen removal. The results indicate that treated effluent could be used with no restriction for irrigated agriculture based on WHO regulation. Also the addition of a denitrification basin reduced nitrate level by more than 80%. The use of reed beds allowed a polishing of both the bacteriological, organic, and nitrogen level in the treated effluent.

The wastewater treatment facility includes influent screening, grit removal, anaerobic lagoons, denitrification lagoons, and flow holding basins. The effluent from the wastewater treatment facility will be passed through recirculating sand filters and reed beds (man-made constructed wetlands) to further reduce solids, organics, pathogens, and nitrogen to the performance of the plant allowed us to produce an effluent that meet the World Health Organization (WHO) standards for unrestricted agricultural irrigation water. No chemicals or complex mechanical equipment are required in the treatment process. The effluent from the wastewater treatment facility will be stored on-site in lined basins and pumped to local farms for use as irrigation water. Crops grown in the local area include alfalfa, clover, corn, wheat, corn, and vegetables. The wastewater treatment facility will receive income from the sale of the irrigation water, the sale of reeds, and the sale of composted sludge. The Commune of Drarga that operates the water distribution system for the town will operate the wastewater treatment and reuse facility as well.

INTRODUCTION

Most countries in the Mediterranean region are arid or semi-arid. They have low rainfall, mostly seasonal and with erratic distribution. Moreover, due to the rapid development of urban and rural domestic water supplies, conventional water resources have been seriously depleted and waste water reclamation and irrigation gained increasing role in the planning and development of additional water supplies.

The WRS Project (Water Resources Sustainability) is intended to improve water resources management by completing three demonstration pilot projects. The WRS Project supports the efforts of the Moroccan Ministry of the Environment and its partners to protect water resources in Morocco and fulfills Strategic Objective No.2 of USAID/Morocco, which is "to improve the management of water resources in the agricultural, urban, and industrial sectors." WRS Project has decided to take a very pragmatic approach that involves completing three pilot demonstration projects, including treatment and reuse of domestic wastewater in the Agadir region. The other two projects are the recovery of chrome discharged by tanneries in *Dokkarat* in Fez and reduction of soil erosion in the *Oued Nakhla* watershed in the Rif.

SITE SELECTION AND COMMUNITY INVOLVEMENT

The town of Drarga was selected as the most appropriate location for the WRS pilot project on the treatment and reuse of domestic wastewater. Of the four districts in the Agadir province that are not included in the Master Plan for Sewage Management of Grand Agadir (Drarga, L'qliâa, Ouled Dahou, and Temsia), only the town of Drarga, in the rural district of Drarga, was equipped with an existing sewerage system (but not a sewage treatment plant). Moreover, the town of Drarga is close to nearby agricultural areas that could be economically irrigated by the treated wastewater.

Fig. 1. Map of Morocco

The Municipality of Drarga is a rapidly expanding town with an efficient central planning organization. Two large housing developments financed by ERAC-Sud are under construction within the district limits. The entire town has been electrified, and a water distribution system serves most of the town. In addition, the town has a sewage collection system that covers about 80% of the town's population. The water and sewage services are provided by the Municipality of Drarga.

Current discharges of untreated wastewater in the town of Drarga pollute ground water, emit unpleasant odors, and are a threat to public health. Wastewater from the town of Drarga is drained through four drainage or outfall sewers coming from (1) Iguidar and Ikiou; (2) Drarga Centre, eastern part; (3) Drarga Centre, western part; and (4) Talat Izem. Those outfall sewers take the wastewater directly to undeveloped areas, which in some cases are only a few meters from residential areas (outfall sewers 3 and 4). The wastewater accumulates in ponds (particularly for discharge points 1 and 2), and a part of it infiltrates into the ground. These ponds promote the development of parasites and insects and give off unpleasant odors. In addition, nitrogen in the wastewater was identified as a contributor to the high nitrate concentrations in the local groundwater (although agriculture is the primary contributor).

As the first step in the project development, potential sites for the treatment plant were identified and compared. The main evaluation criteria for the selection of the site were as follows:

1. Distance between the site and the population center (impact of odors)
2. Ownership of the site (private or public land)
3. Access to the site
4. Conveyance to the site of untreated wastewater
5. Topography and geology of the site
6. Risks of flooding
7. Risks of polluting groundwater
8. Proximity to users of treated wastewater
9. Room for future expansion

Based on these criteria, four potential sites were established and evaluated. The most favorable site was selected and acquired by the municipality.

Development of Design Criteria

Average wastewater flow rates at the four existing sewage outfalls in the Municipality of Drarga were measured in May 1997. This flow data was compared to the current number of customers connected to the existing sewage system to determine an average wastewater generation rate per capita. In addition, the following additional parameters were examined: the connection rate of customers to the existing municipal water and sewage systems, the average drinking water consumption for customers connected and unconnected to the municipal system, the average ratio of water consumption to sewage flow for customers connected to both systems, and the historical changes in per-capita water usage in the municipality. Based on this data and population growth estimates for the municipality, the required design capacity for the wastewater treatment facility was developed for a 20-year period. These estimates assume that the existing municipal water and sewage system will continue to expand until all residents of the municipality are connected. The estimates also assume that per capita water consumption (and thus sewage generation) in the municipality will continue to increase from a current rate of 46 L/capita/day to a projected rate of 65 L/capita/day in the year 2020 as the area modernizes and expands.

Table 2. Population and Influent Flow

	YEAR 2000	**YEAR 2010**	**YEAR 2020**
Population (Estimated)	7,300	11,300	17,600
Percent of Population Connected to Sewer System	80 %	90 %	100 %
Design Average Wastewater Flow per Capita (1)	41.6 L/d	59.7 L/d	67.3 L/d
Design Wastewater Flow Rate (Average Daily Flow)	243 m^3/d	607 m^3/d	1,184 m^3/d
Peak Hour Flow Rate (2)	437 m^3/d	1,090 m^3/d	2,130 m^3/d

Notes :(1) Average wastewater flow rate estimates include 10% safety margin.
(2) Peak hour flow rate based on an observed diurnal peak hour factor of 1.8.

Wastewater sampling was conducted in February 1998 to collect additional data on the composition and diurnal flow variation of the domestic wastewater generated in the Municipality. This data was used to establish the design influent sewage characterization upon which the facility design is based on. The design assumes that the *concentrations* of contaminants in the influent sewage will decrease in the future with the modernization of the municipality. This will occur because although the per capita water consumption rate is anticipated to increase in the future, the overall waste generation rate per person will remain relatively constant.

Table 3. Influent Sewage Characterization (Design Concentrations)

YEAR	TSS (MG/L)	COD (MG/L)	BOD_5 (MG/L)	TKN (MG/L)	TP (MG/L)
Current	1070	2350	1220	210	30
2000	886	1946	1010	174	25
2010	656	1441	748	129	18
2020	530	1164	604	104	15

The treated effluent water quality design standards for the facility were developed based on local water quality goals as well as WHO and UN-FAO standards. Of primary importance was the limitation of nitrate concentration in the reuse water, because although the presence of some nitrogen in the irrigation water will act as a beneficial nutrient for crop growth, any excess water seeping into the ground will eventually enter the groundwater supply aquifer for the area. Nitrate contamination of groundwater is a significant problem in this area, with 26% of the local wells analyzed exceeding the recommended nitrate limit for drinking water of 50 mg/L and an additional 40% of the wells having nitrate concentrations between 25 and 50 mg/L. A goal of 30 mg/L effluent nitrate-nitrogen concentration was developed based on UN-FAO guidelines and the limitations in treatment performance expected with the selected low-technology treatment process. Also important was to limit the concentration of pathogens in the reuse water. For this purpose, the 1989 WHO standards for unrestricted irrigation of edible crops (less than 1,000 fecal coliforms per 100 mL and less than 1 intestinal nematode egg per liter) were selected to provide maximum protection against disease transfer. Four primary performance indicators were selected for ease in monitoring the performance of the treatment process.

In addition to effluent reuse for agricultural irrigation, another goal of the project was to include reed beds for the growth of giant reeds for sale as a commercial product. Also, sludge dewatering facilities were requested so that sludge produced at the facility could be co-composted with municipal solid waste and used as an organic soil amendment.

WASTEWATER TREATMENT PROCESS DESCRIPTION

The demonstration treatment facility is situated in the southwest corner of the Municipality on land formerly used for agriculture. The site is bordered on the west by the Oued Irhzer El Arba, a dry river which drains into the Oued Souss and on the east by the right-of-way for a future rail line which is planned for the region in the year 2050. The selected site has about 5.6 hectares of land area available for construction and is relatively flat. As discussed earlier, the goal of the project was to design a plant capable of reaching the target concentrations shown in Table 4. Although the treatment plant was designed to meet the year 2020 wastewater flow, during the initial stage of the project, only the facilities necessary to meet the year 2010 design flow are being constructed. Two supplementary projects were also required to implement the wastewater treatment process; construction of flood protection improvements along the Oued Irhzer El Arba (which is subject to seasonal flooding) and extension of the existing sewer system from the four current outfall points to the treatment plant site. A step-by-step description of the treatment plant components follows.

Table 4. Target Effluent Concentrations for Performance Indicators

YEAR	BOD_5 (MG/L)	NO_3-N [(1)] (MG/L)	TN [(1)] (MG/L)	FECAL COLIFORMS (MPN/100 ML)
2000	< 30	< 30	< 38	< 1000
2010	< 30	< 30	< 38	< 1000
2020	< 30	< 30	< 38	< 1000

Notes: 1. Targeted nitrogen concentrations in RSF effluent. Effluent nitrogen concentration from Reed Beds will vary with the amount of evapotranpiration.

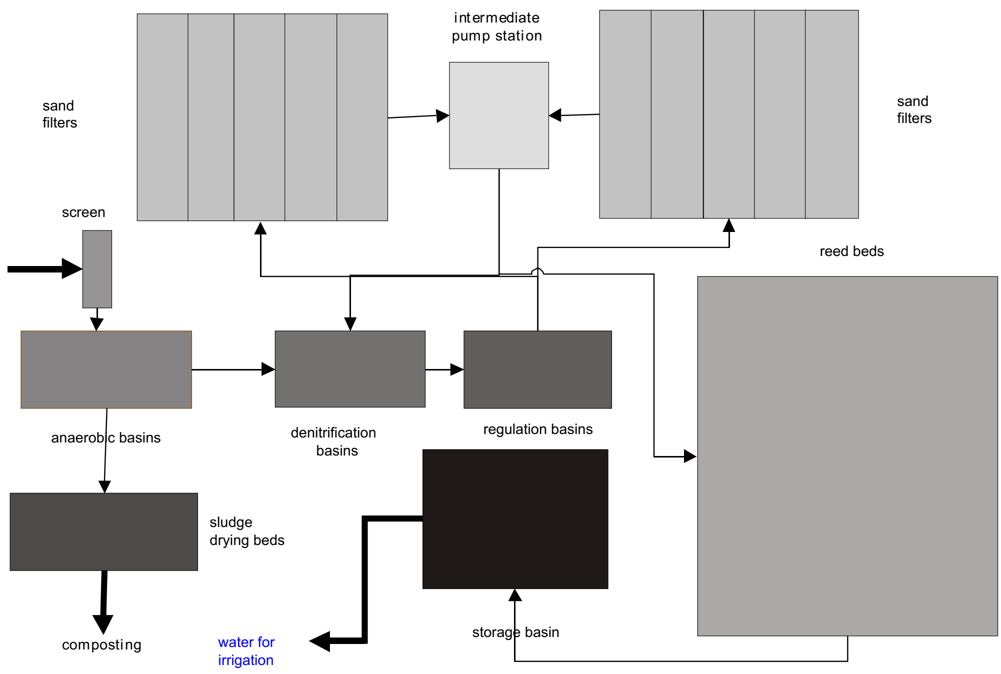


Fig. 4. Site Plan of Drarga Wastewater Treatment Plant

Bypass Chamber

The bypass chamber is the first structure in the wastewater treatment plant. Normally, all of the wastewater flow generated by the Municipality will be treated at the plant. However, during heavy rain events, a large quantity of rainwater may enter the collection sewer system through inflow and infiltration. This rainwater will dilute the strength of the sewage, but it will also increase the quantity of sewage above what the treatment plant is capable of handling. During such periods, the treatment plant will continue to function at full hydraulic capacity, while any additional flow will bypass to the intermediate pump station from where the combined raw sewage and recirculating sand filter effluent will be pumped into the Oued Irhzer El Arba. It is anticipated that this situation will occur very infrequently, and when it does the Oued Irhzer El Arba will be flowing with water which will further dilute the bypassed sewage.

Screening

The first step of the treatment process is to remove large floating and suspended solids, rags, rocks, debris, and other large objects from the influent wastewater. These objects will be captured in the manually cleaned influent bar screen located immediately downstream of the bypass chamber. Influent screening is important because large solids and rags could potentially clog downstream pumps, pipes, and valves if not removed at this time.

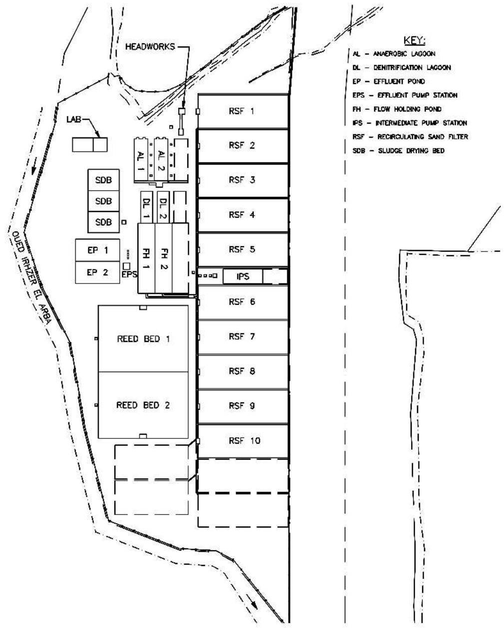
Grit Removal

The next step of the treatment process is grit removal, which occurs in two parallel grit removal chambers. Dense solids such as sand or bone fragments will settle to the bottom of this chamber, from which they must be shoveled out by hand. A proportional weir at the end of each chamber maintains a constant flow velocity through the chamber. This constant velocity ensures that biodegradable organic solids, which are typically less dense than grit, will not settle inadvertently in the grit removal chamber.

Flow Distribution

There are three flow distribution boxes in the plant: Flow Distribution Box No. 1, Flow Distribution Box No. 2, and the Nitrate Recycle Flow Distribution Box. These boxes are used to spilt the wastewater flow evenly between all process tanks on line by flow over equal length sharp-crested weirs set at the same height.

In addition, the Nitrate Recycle Flow Distribution Box allows the RSF effluent pumped from the intermediate pump station to be distributed proportionally between the denitrification lagoons and the reed beds. By using stop plates to cover some of these weirs, the operators can achieve a 3:1, 2.4:1, 1.8:1, 1.2:1, or 0.6:1 ratio of nitrate recycle to plant influent. The design nitrate recycle ratio is 2.4 for the year 2010 design and 1.8 for the year 2020 design. The ratio is lower for the future design condition because the nitrogen concentration in the plant influent is expected to decrease with modernization of the area (see Development of Design Criteria, above).



Anaerobic Lagoons

The purpose of the anaerobic lagoons is to remove COD present in the influent wastewater through anaerobic biological decomposition. At the same time, suspended solids present in the influent wastewater and the bacteria that grow as a result of the anaerobic activity will settle to the bottom of the lagoon. There are two anaerobic lagoons in the year 2010 design. A third lagoon will be added in the future expansion to the year 2020 design flow. Each lagoon has a volume of 918 m^3 and the units combine to provide a 3.0 day hydraulic detention time (HRT) for the year 2010 design flow, and a 2.3 day HRT for the year 2020 design flow. The anaerobic biological decomposition process generates methane gas and carbon dioxide as a byproduct. Floating covers over the lagoon capture this gas. Collection piping carries the gas to a 16 kW engine generator, which converts the energy in the methane gas into electricity. The electricity can be used to power the operator's house, laboratory, and selected pumps. Submersible sludge pumps in the bottom of the lagoon can be used to pump the sludge out of the lagoon onto the sludge drying beds for dewatering.

Denitrification Lagoons

The purpose of the denitrification lagoons is to remove oxidized nitrogen (nitrate and nitrite) by the biological process of denitrification. This process is carried out by heterotrophic bacteria operating in an anoxic environment. The bacteria require a carbon source to carry out the denitrification process. The carbon source in this application is the COD present in the anaerobic lagoon effluent wastewater. Additional COD can be supplied by directly bypassing a portion of the influent wastewater from Flow Distribution Box No. 1 around the anaerobic lagoons. The effluent from the anaerobic lagoons contains most of the nitrogen present in the form of TKN. Therefore, a portion of the effluent from the RSFs (in which the nitrification process has converted ammonia into oxidized nitrogen) must be recycled back to the denitrification lagoons. This is accomplished by the Nitrate Recycle Flow Distribution Box. Like the anaerobic lagoons, the denitrification lagoons contain submersible sludge pumps that can be used to pump settled solids out of the lagoons and onto a sludge drying bed for dewatering. There are two denitrification lagoons in the year 2010 design. A third lagoon will be added in the future expansion to the year 2020 design flow. Each lagoon has a volume of 736 m^3 and the units combine to provide a 2.4 day nominal HRT for the year 2010 design flow, and a 1.9 day nominal HRT for the year 2020 design flow.

Flow Holding Basin

The purpose of the flow holding basin is to store the effluent from the denitrification lagoons until it is time to dose the next sand filter. The sand filters are dosed three time per day, so the combined volume of the flow holding basins are equal to one-third of the total volume of influent flow and nitrate recycle flow for one day. At pre-set intervals during the day, the operators will manually open the sluice gate at the end of the flow holding basin, releasing the contents of the basin to the RSFs. There will be relatively few solids present in the flow leaving the denitrification lagoons, but some additional solids may settle out in the flow holding basins and can be removed periodically by draining the foot of the basin into the recycle pump station. There are two flow holding basins in the year 2010 design. A third basin will be added in the future expansion to the year 2020 design flow. Each basin has a volume of 360 m^3.

Recirculating Sand Filters

The primary purpose of the recirculating sand filters (RSFs) is nitrification (the biological process by which ammonia is converted to nitrate by autotrophic bacteria under aerobic conditions). Additional reduction of BOD and some degree of denitrification will also take place in the RSFs. The denitrification is possible in portions of the RSF which do not receive adequate oxygen. The primary source of oxygen in the RSFs is diffusion of oxygen into the upper layers of the sand from the air. This effect is enhanced by frequent "tilling" of the sand on the surface. The tilling process involves turning the top few centimeters of sand to expose the bacteria growing on the sand grains to the surface air. The tilling process also breaks up the hard pan of solids and algae that tends to build up on the RSF surface over time. Some oxygen will also enter the bottom of the RSF through the open underdrains. There are ten RSFs built for the Year 2010 design flow. An addition four RSFs will be constructed for the year 2020 design flow. Two RSFs will be dosed at a time for the Year 2010 design, and three at a time for the Year 2020 design. Each RSF has a surface area of 1560 m^2 and at the design dosing rate of 360 m^3 per sand filter, the hydraulic loading will be 230 mm per dose. Each RSF is dosed once every five dosing periods. There are three dosing periods each day. In each dosing periods, the slide gate at the end of both flow holding basins is opened, sending a rush of stored wastewater onto the surface of two of the RSFs. The flow of wastewater onto the RSF surface is faster than the liquid can percolate through the sand, so the liquid ponds on top of the sand surface. The ponding results in an even depth of wastewater over the entire RSF surface, which in turn, ensures an even distribution of flow across all parts of the RSF. Over the next several hours, the ponded water percolates through the sand particles, where attached bacteria carry out the nitrification process. The close packing of the sand grains also filters out solids. In addition, studies at Ben Sergao have indicated that significant pathogen reduction occurs across the sand filters, both from filtration and from natural die-off of bacteria, which is largely a function of time and temperature.

Intermediate Pump Station

The effluent from the RSFs drains into the intermediate pump station. The maximum water level in the intermediate pump station must be kept below the bottom of the RSFs to allow the RSFs to drain completely. Due to the great depth below the ground surface at this point, submersible wastewater pumps are used to lift the wastewater back up to the surface level. These pumps serve a dual purpose, as they also return a portion of the RSF effluent back to the front end of the denitrification lagoons to serve as a source of nitrates for the denitrification process. The intermediate pump station has a large volume so that it can act as a flow equalization point. Even though liquid exits the RSFs at an inconsistent rate (due to the periodic loading method), the RSF effluent flow will be equalized in the intermediate pump station and (when properly adjusted) the pumps will operate at a constant rate throughout the 24-hour period.

Reed Beds

There are two reed beds, each about 2,900 m^2 in area. These membrane lined beds, which are subsurface irrigated with a constant water depth of 1.0 m, will be planted with local varieties of fast-growing giant reeds (qchqlich and aghanin) in alternating rows. The primary purpose of the reed beds is to grow reeds that will be harvested periodically and sold as a source of income for the plant. The reed beds will also remove some nitrogen and other nutrients from the wastewater by uptake into the plants and by biological nutrient removal. This nitrogen removal, however, will be partially off-set during many parts of the year by the loss of water through the basins due to evapotranspiration. Thus, although the nitrogen load (in kg/d) will decrease across the reed beds, the change of nitrogen concentration across the reed beds is highly dependent on the percentage of water loss across the reed beds. The concentration can increase or decrease.

Effluent Storage Ponds and Pump Station

There are two effluent storage ponds, each with a volume of 1,014 m^3. The effluent flow storage ponds store treated effluent from the plant until it is needed by the local farmers. The effluent pump station pumps treated plant effluent from the effluent flow storage ponds to the farmer's fields for use as irrigation water. A flowmeter is used to measure the quantity of irrigation water delivered to the farmers. Irrigation water will be distributed among the eligible farmers through a piping distribution network. Valves will be installed at each farm parcel and controlled under the authority of a “gouadier” (according to the traditional rules of the region). Major crops to be developed include alfalfa, clover, corn, bananas, zucchini, pumpkin, cabbage, potato, and onion. Water may be allocated for cereal crops, such as wheat, during certain crucial growing periods (such as the ripening period). The reuse water will provide a significant source of nutrients (nitrogen, phosphorus, and potassium) to the irrigated crops without excessive contribution of nitrates to the groundwater. Excess water which is not required by the farmers will overflow the storage ponds and into the adjacent Oued Irhzer El Arba.

Sludge Drying Beds

The purpose of the sludge drying beds is to dewater sludge produced in the anaerobic lagoons and the denitrification lagoons. The liquid sludge is pumped from the bottom of the lagoons by submersible pumps and onto the surface of the sludge drying beds. The liquid portion of the sludge will evaporate into the atmosphere or drain through the sand in the drying beds into the underdrain below. The underdrain is piped back to the anaerobic lagoon effluent channel. The dried sludge must be removed with a small loader and disposed of or used for co-composting with municipal solid waste. The on-site municipal solid waste/wastewater sludge co-composting project is currently under design through a separately funded project.

There are five sources of nitrogen removal in this treatment system.
Nitrogen contained in sludge removed from the anaerobic lagoons.
Nitrogen contained in sludge removed from the denitrification lagoons.
Nitrates (from the RSF effluent) recycled in the nitrate recycle flow and denitrified in the denitrification lagoon.
Ammonia nitrified (converted to nitrates) in the RSFs and immediately denitrified in anoxic regions of the same filter.
Nitrogen contained in the harvested reeds.

At the same time, the nitrogen *concentration* through the treatment system is increased by water losses from the system through evaporation, transpiration, and plant uptake. The overall result is an anticipated reduction in the total nitrogen across the facility of 70% (in the year 2010) and 63% (in the year 2020).

Performance of the plant in reducing water pollution

Test conducted at the plant during the period of 2000- 2002 show that the facility was meeting the targets set for reducing water pollution in Drarga. Table 5 below shows the levels after the establishment of the treatment plant. The quantity of treated wastewater generated from the plant was about 400 m^3 per day.

Table 5. Drarga wastewater treatment plant performance

	Raw waste water		After anaerobic lagoon		After sand filter		After reed bed		Reduction %	
Parameters	Saison		Saison		Saison		Saison		Saison	
	Cold	Warm	Cold	Warm	Cold	Warm	Cold	Warm	Cold	Warm
N-NH4 mg/l	182	170	177	165	0.8	0.6	0.6	0.5	99.6	99.7
N-NO3 mg/l	0.05	0.10	0.08	0.11	48	59	38	45		
NTK mg/l	297	317	121	118	18	12	15	10	95	96.8
DBO5 mg/l	709	625	332	256	12	10	14	9	98	98.5
DCO mg/l	1345	1033	584	417	71	56	69	56	94.8	94.5
CF/100 ml	$6.4\ 10^6$	$1.6\ 10^7$	$6.1\ 10^5$	$6.7\ 10^5$	$2.0\ 10^3$	790	170	500	99.99	99.99
Helminthes/l	4	5	3	4	0	0	0	0	100	100
Conductivity dS/m	2.8	2.4	2.9	2.5	2.8	2.7	2.4	2.2		

WATER SAVING

The water wastewater fulfills the requirements of world health organization without restriction. The WRS project increased farmers' awareness on the use of treated wastewater for crop irrigation by developing demonstration plots using drip irrigation. The results of the demonstration plots convinced the farmers of the benefits of using treated water for irrigation. Crops that are irrigated with treated influents in the demonstration plots includes cereals (wheat, maize) , vegetables (tomatoes and zucchini), and forage crops (alfalfa, ray grasses).

In 2001, the commune of Drarga started operating the treatment plant and provided treated wastewater to a few farmers to irrigate fields in the irrigated perimeters of 6 Ha around construction site of the plant. Currently, farmers grow forage crops, particularly alfalfa, clover, maize, and others vegetables crops.

The farmers irrigating with treated water are benefiting in two ways. First, they have access to guaranteed amount of low priced water. In addition, they can economize on buying fertilizers since the treated wastewater already contains nutrients elements needed by the crops.

Table 6 summarizes the economic saving of water and fertilizers for each crop. The total economic saving ranges from 222 euro per ha up to 514 euro per ha respectively for zucchini and for maize.

Table 6. Economic saving of water and fertilizers for crops irrigated with treated wastewater

Crop	Water savings (DH/ha)	Fertilizer Savings (DH/ha)	Total Savings (DH/ha)
Wheat	750	1492	2242
Maize	1588	3614	5140
Alfalfa	774	1539	2313
Zucchini	677	1545	222
Tomato	1553	3542	5059

COST RCOVERY

The Drarga wastewater treatment and reuse project was conceived with cost recovery features in mind. In Morocco, nearly 70% of wastewater treatment plants are not functioning due to luck of spears parts and poor cost recovery. The Drarga project includes several cost recovery features. The plant it self generates a number of products that have the marked value:

Treated wastewater is sold to farmers for irrigation;
Reeds from the reed beds are harvested and sold twice a year;
Residual sludge from the anaerobic basins are pumped, dried, and combined with organic wastes from Drarga to produce compost;
The methane gas from the anaerobic basins is recovered and converted to energy to run pumps at the plant, thereby reducing electricity costs.

In addition to the products from the plant, the commune is committed to raise revenues to pay for the operations, maintenance, and replacement costs of the plant. These revenues include:

An increase of 1 Dirham ($0.10) per cubic meter to the water and sewage tariff;
An increase of 1,500 Dirham ($150) to the one time sewage connection charge for new connections.

These revenues, combined with revenues from the plant are deposited into a special account that is independent of the commune's account is further divided into two sub accounts: (1) an operations account for current expenses, and (2) an extension and renewal account the future expansion of the wastewater treatment plant.

The project provided the commune Drarga with a spreadsheet model to manage all financial aspects of the plant.