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BEST MANAGEMENT PRACTICES FOR SUSTAINABLE REUSE OF TREATED WASTEWATER

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ABSTRACT – Agriculture application of recycled water is currently practiced in many countries in the Mediterranean basin to beneficially use the nutrients in recycled water for crop production and reduce the direct discharge of pollutants into inland and coastal waters. However, treated wastewaters are unique in composition, often associated with environmental and health risks. Thus, the effect of treated effluent on crops, soil and communities health must be considered carefully. Nevertheless, there is a need to study, the impact of treated wastewater on high value horticultural crops and on cereal crops. The aims of this paper is to review ten years of field research on the fate of the faecal coliforms and nutrients during the application of reclaimed wastewater to develop the best management for growing vegetables, flowers, and cereal crops species under Arid condition in the southern part of Morocco.

Key words: Morocco, treated wastewater, Best Management Practices (BMP), cereals, vegetables, flowers

INTRODUCTION

Since the sixties, Morocco has emphasis all his effort on maximizing the capture of the country's surface water and encouraging for their optimal use in irrigated agriculture. In Morocco, there are approximately 7.7 millions of arable lands of which one million ha are actually irrigated and the rest is under rainfed irrigation. High cash crops are the major crops cultivated under irrigation and wheat dominant the crops grown under rainfed conditions. Wheat production in arid regions of morocco is very dependent on rainfall. Frequent droughts took place during the spring that corresponds to flowering or grain filling stage depending on the planting date. Rational use of irrigation water, by adopting adequate drip irrigation for high value cash crops and the use of supplemental irrigation is widely recommended to stabilize and to improve crop yield. However with the scarcity of high quality water resources, the use of marginal waters (saline water and treated wastewater) is not only a necessity, but also an inevitable option to alleviate the water crisis in these regions.

Due to the pronounced water deficit, Agadir region is using sand infiltration system to treat its wastewater to be reused in agriculture and landscaping. This technology generates high nitrate concentration in the effluent (more than 500 mg/l). This indicates the high risk of nitrate leaching and nitrogen pollution of the ground water. This risk is amplified by the soil type (sandy soils) and the hydro-geologic analysis of this studied region. The acceptability of wastewater to replace conventional water resources is highly dependent whether the health risks and the environmental impacts (salinity, nitrate pollution) are within acceptable levels. The needs for improving wastewater-use efficiency (WUE) in agricultural production and sustainable reuse of treated wastewater are clearly urgent. Our objectives is to optimize the use of wastewater for maximum crop yield or profit, but taking into account the cost of the irrigation water and minimizing the risks for soil salinity and deep percolation of nitrate. Several experiments were undertaken during the last six years within the framework of a collaborative research studies between the Institute of Agronomy and Veterinary Hassan II, Agadir, and the Institute of Agronomy of Bari, with the aims to develop irrigation techniques using treated wastewater, compatible with sustainable agriculture practices:

For vegetables and flower crops our objectives were to:

(i) Master the water-nitrogen interactions by increasing the water efficiency and reducing the nitrate leaching by testing different rates of water.

(ii) Evaluate the water and the nitrogen use by different crops taking into account their nitrogen and water requirement.
(iii) Evaluate the potential risk of ground water pollution and salt accumulation for the different treatments.

For wheat we adopted supplemental irrigation order to:

(i) Determine the optimum water depth under supplementary irrigation practice.
(ii) Evaluate the effects of supplementary irrigation on the crop development, flowering, and grain yield.
(iii) Determine the impacts of applying treated effluent on the soil characteristics and the plant nutrition.
(iv) Test the suitability of the modern irrigation technique “Mini-sprinklers“ , using treated wastewater.

MATERIAL AND METHODS

The first three years experiments were conducted under plastic tunnel for vegetables and cut flowers, and in the open field for cereal’s crops at the station of the O.R.M.V.A/SM, located in Bensergao, 5 Km south of Agadir city. The forth to the sixth year experiments was conducted under open field for both vegetables and wheat on a sandy-loamy soil in the open field at the rural commune of Drarga near the city of Agadir.

First Year Experiments

Using drip irrigation, and 120%ETM regime we compared three type of irrigation water (sand infiltration treated wastewater, epuvalisation treated wastewater, well water to which we added nutrients).we also compared two varieties of eggplants and geranium.

For cereal’s crops (maize, durum wheat, bread wheat, barley) we applied increasing regime of irrigation water (100, 110, 120%ETM) and compared two type of water (sand filter treated wastewater, well water to which we added nutrients). Also we had a control treatment for which plants were irrigated at the germination stage and for the rest of the cycle they were under rainfed conditions.

Table 1. Physicochemical characteristics of the irrigation treated wastewater used in our experiments

Characteristics	Sand infiltration (Bensergao)	Sand infiltration + denitrification+ reed bed (Drarga)
CE dS/m	3	2.61
pH	7.41	7.6
NO_3^- ppm	651	49
NH_4^+ ppm	1,8	18
K^+ ppm	46,8	20.28
PO_4^{3-} ppm	42.2	2.4
Cl- ppm	603	515
Ca^{++} ppm	169	219
Na^+ ppm	228	176
Mg^{++} ppm	90	62
CO_3^{---} ppm	0	8.5
$HCO_3^{—}$ ppm	-	662
SAR	-	2.69
MES mg/l	10	5
Coliformes (Nbr/100ml)	< 1000	<600
Streptocoques (Nbr/100ml)	< 1000	-
Œufs d’helminthes (Nbr/l)	0	0

Second Year Experiments

Using drip irrigation, several irrigation regime were applied on chrysanthemum (60, 80, 100, 120%ETM) and on zucchini (100, 120% ETM) and we also compared treated wastewater to well water to which we added nutrients.

For wheat crop we applied increasing dose of treated wastewater (100, 200, 300, 400 mm) using micro-sprinklers.

Third Year Experiments

Using drip irrigation system, three irrigation practices were applied; (i) treated wastewater rich in nitrate nitrogen (651 mg/l), (ii) saline well water to which we added nutrients according to crop requirements, (iii) alternating well water with treated wastewater based on the nitrogen requirements of chrysanthemum and pepper crop. During the first growing stage of these two crops, we used well water since needs for nitrogen is very limited, and during the vegetative growth and fruit development we switch to treated wastewater. The combination of these three treatments with two water regimes (100% ETM and 120% ETM) resulted in six treatments randomly distribute in a Latin scare design. Six lyzimeters of 1 m^2 corresponding to each treatment were installed to collect leachate in order to monitor water and nitrogen balance during the crop cycle. Soil samples were analyzed for nitrogen contents before planting and at the end of the harvest. Total yield for four month growing cycle was recorded for each treatment.

For wheat crop we compared five irrigation doses (250, 275, 300, 350, 400 mm) to rainfed treatments

Fourth to the Sixth Year Experiments

Using drip irrigation system, two water regime (100% ETM, and 120% ETM) were applied; and four vegetable crops (green beans, tomato, potato, zucchini) were evaluated for their growth and yield responses).

Four lyzimeters of 2m^2 corresponding to the treatment 120%were installed to collect leachate in order to monitor water and nitrogen balance during the crop cycle. The plant response evaluation, in terms of mineral content, dry matter, quality of the fruits, and total nitrogen leached from the soil solution was collected in the lyzimeters. Salts accumulation were also monitored during the whole crops cycle by measuring the saturated paste electrical conductivity of the soil under the two water.

Soil samples were analyzed for nitrogen contents before planting and at the end of the harvest and total yield for seven months growing cycle was recorded for each treatment.

Wheat experiment was undertaken using the same treated wastewater and applied two doses of irrigation water (200, 350 mm) throughout all the crop growth stages. The entire field has received the same amount of water, which was equal to 100 mm in the vegetative stage (germination + tillering),

Starting from the flowering stage the irrigation amount is (D1-100 mm) and (D2-250 mm), was allocated according to the schedule (S1, S2, S3) between the flowering stage (F) and the grain filling stage (G) as following:

S1: 50% at (F) and 50% at (G).
S2: 70% at (F) and 30% at (G)
S3: 30% at (F) and 70% at (G).

The control plants received also the same amount of water (100mm) up to the flowering stage, after which no irrigation was added, and the plants water requirements depended on the rainfall. The experiment design adopted for our experiment was a split plot with six repetitions. The cultivars of the bread wheat used in our experiment was *Marchouch.*

In this trail, we used the mini-sprinkler irrigation system which known as *micro jet sprinkler*. Its discharge ranges between 40-50 l/h, according to the water pressure, and each sprinkler covers (1 m^2).

The objectives of all these studies were to find the answers to two questions: (i) which irrigation management is optimal, considering both crop production and reduction of nitrates leaching, in the relation to the need for increasing water use efficiency? (ii) Does the use of different depth of irrigation lead to conciliate between nitrogen pollution and salt build up in the soil? (iii) Does alternating fresh water with treated wastewater could alleviate the salt build up and nitrate pollution?

RESULTS AND DISCUSSION

Crop Yield Response

In most cases of arid and semi-arid areas of the world, the shortage of water is increasing the interest for the recycling of treated wastewater in agriculture. Our research gives a clear picture on the use of unconventional water to get higher water use efficiency without decrease in yield.

As matter of fact, yields were higher for plants irrigated with treated wastewater (Table 2). The increase of yield for plants receiving 20% more water is mainly due to more supply of nitrogen and lower salinity in the roots zone. The water use efficiency was significantly different between treated wastewater and saline well water. Water use efficiency was the highest for the plants receiving treated wastewater at 120%ETM.

Table 2. Response of several crops to treated wastewater irrigation

Treatments	Chrysanthemum	Zucchini	Egg plant	Maize	Bread wheat	Hard wheat
	Flower/plt	(Kg/plt)	(Kg/m^2)	Qx/ha	Qx/ha	Qx/ha
Control *	69	1.29	3.17	12.43	5.107	0
Treated wastewater	80	2.18	3.41	12.62	48.69	31.83

* In the case of vegetable and flower control correspond to well water with added fertilizers and for cereals control correspond to rainfed conditions.

Alternation of Saline Water with Treated Wastewater

The alternation of saline water with treated wastewater increased the water use efficiency and reduces by 50% the total nitrogen lost under treatment irrigated with treated wastewater. It appears that changes in irrigation management, as demonstrated in these studies reduce the download flux of nitrogen to the ground water, resulting in lower nitrates concentration compared to plants irrigated during the whole cycle with treated wastewater. Water and nutrients must be supplied in correspondence with their uptake to prevent the occurrence of nutrients deficiencies, salinization or pollution. As treated wastewater nutrient concentration is constant, it appears from our results that alternating saline water with treated wastewater reduce considerably nitrogen leaching and increase nitrogen efficiency.

Clogging

Suspended solid materials (SSM) are responsible for the soil clogging. The latest could be physical or biological.

The physical clogging consists of the obstruction of the soil porosity at the level by SSM. This causes a significant reduction of the water infiltration and aeration. So, anaerobic conditions settle down and lead to the decrease of the biological activity of the soil microflora and respiratory activity of the plant roots. Gas exchange between atmosphere and soil is also decreased under these conditions. In clogged soils, water will rather tend to stream instead of infiltrating where from the risks of erosion.

It is important to underline that the vertical distribution of SSM in the porosity of the soil varies with the soil texture in the soil profile. So, the clayey soils are more vulnerable than sandy soils because the dominance of the micro-porosity.

The biological clogging follows on the physical clogging. It results from the activation of the microbial population (bacteria and fungus) in an environment enriched by mineral and organic materials. Active metabolism generates the production of some metabolites and exudates like gum. These substances participate to the clogging.

It is however important to indicate that SSM contain an important proportion of organic matters which enriches the soil.

Nitrogen Loads in the Treated Wastewater

The nitrogen loads in the treated effluent depend essentially on the wastewater treatment technology. The lagoon system constructed in Ouarzazate (Morocco) produce a level of ammonium nitrogen in the treated effluent of 25 mg/l, 35mg of total nitrogen and minor quantity of nitrogen in the nitrate form. The infiltration percolation system used in Ben Sergao locality (Agadir/Morocco) produce effluent with high concentration level of nitrogen in the nitrate form which could reach up to 600mg/l. This technology oxidizes most of the ammonium nitrogen, which is the dominant form in the wastewater to nitrate. This process of nitrification is running at its optimum since both the temperature and water condition are favourable to the oxidation of ammonium that is available in the wastewater. In the commune of Drarga (Agadir/Morocco) this technology was reinforced by adding a biological denitrification process based on recycling part of the treated Wastewater to the pre-treated Wastewater in order to add a source of carbon needed by the endogenous bacteria for their respiration .A tertiary treatment using reeds was also added to this process. This will reduce nitrate concentration since the reed biomass will mobilise around 8% of nitrogen in their dry matter .We can conclude from these observation that the nutrient valorisation, particularly nitrogen could take in count the adapted technology.

Nitrate Leaching

Treated waste water used in our experiment is very rich in nitrate nitrogen, since the infiltration-percolation system used for treating waste water oxidize most of nitrogen content. Therefore, the total nitrate leached was very high and reduced the efficiency of nitrogen uptake for sweet pepper irrigated with treated wastewater. This presents a risk for ground water nitrate pollution and limits the reuse of treated wastewater unless best management practices are used to reduce nitrogen loading.

The results for nitrogen pollution risk for irrigating sweet pepper show that there’s a significant difference between the irrigation management options. The quantity of nitrogen leached in treatments irrigated with treated wastewater were five times higher for plants irrigated with 100%ETM and 3.5 times for 120%ETM regime compared to treatments irrigated with saline well water with added fertilizers.

Alternating saline well water with treated wastewater reduce the nitrogen loading to the groundwater by 50%. This practice allows to satisfy the nitrogen requirements of sweet pepper during the early stage by using well saline water when nitrogen requirement of the plant are very low and then irrigate plant with treated wastewater during the vegetative and the fruit development stages with treated wastewater.

Wastewater Reuse and Nitrogen Mass Balance

The nitrogen mass balance for the tested crops receiving treated wastewater indicates the high risk of nitrate ground water table. In fact the texture, the high infiltration rate and the high nitrate concentration in the treated effluent contribute to high nitrate leaching potential the amount of nitrogen lost to the underground water are 346 and 343 kg of N/ha respectively for eggplant and chrysanthemum, considering all the components related to nitrogen budget.

Monitoring data of some trial related to melon and carnation crops, conducted in Ben Sergao experimental station, allowed us to quantify of amount of nitrate nitrogen leached using infiltration-percolation treated water for irrigation. This also allowed us to evaluate the potential risk of groundwater nitrate pollution.

The irrigation volumes used for each crop generated nitrate nitrogen supply evaluated up to 2114 kg of NO3/ha and 2397 Kg of NO3/ha respectively for melon and carnation. These value correspond respectively to 477 and 541 unite of nitrogen fertilizer. The quantity of nitrogen taken up respectively by melon and carnation are 260 and 357 kg N/ha. These amounts represent 54,5 and 66% of nitrogen added by irrigation water of melon and carnation respectively. We then conclude that the amount of nitrogen lost to the underground water are 346 and 343 kg of N/ha respectively for melon and carnation, considering all the components related to nitrogen budget.

Considering the low losses due to denitrification in the experimental plots soil, due to the fact that the system is well-aerated and present very low level of carbon source; these volumes of nitrogen losses could be assimilated to nitrate lixiviation.

The amount of nitrate nitrogen that are really leached have been analyzed in the lyzimeter drainage and represent an average of 210 and 115 mg N-NO3/l for the whole cycle of melon and carnation, based on drainage fraction evaluated to 26% of the amount of water added to total quantity of leached nitrate nitrogen is evaluated to 246 and 175,5 kg N/ha for melon and carnation the observed difference between this values and the calculated values using the nitrogen budget method, (that the amount of nitrate in the soil layer between 30 cm and 1 m is lost by leaching. The mass balance is still considered attractive when it is applied for it present a large area and for several crop. Certain disadvantages, since the lyzimeter represent an isolated volume and require tedious measurements.

Water Use Efficiency

Regarding the water efficiency, the results show two mean tendencies:

- The amount of water corresponding to 120% ETM induced high nitrogen leaching and reduced salt accumulation in the root zone. Eventhough, the obtained yield was significantly increased for this water regime.
- The application of an equal amount of the crop requirement induces salt accumulation and reduces the nitrogen leaching and yields. Additional experiments for selected crops showed that water application of 100% ETM during the two first stages characterized by low water requirement and 120% ETM during the last stage of the crop growth reduce the nitrate leaching by 67% and increased the soil salinity by only 25%.

Effect of Water Depth

The studies on cereals crops demonstrate that supplemental irrigation stabilizes bread wheat yield under arid condition of morocco. There is an increase of grain yield of wheat crop from 9.5 qx /ha to 32 qx/hat, when the amount of water increase from 100 mm to 300 mm (Table 3). Plants growing under rainfed condition yielded almost zero production.

Table 3. Effect of increasing amount of treated wastewater on wheat yield and its components

Amount of water	tillers/m^2	grains/tiller	Weight of 1000 grains	Grain yield (g/m^2)	Yield (Qx/ha)	Straw yield (Qx/ha)
100 mm	312	12	25	90	9.4	25.8
200 mm	328	16	22	120	11.5	32.7
300 mm	478	18	37	320	31.8	61.6
400 mm	371	26	17	160	16.4	43.5

Wastewater as Supplement Irrigation

Our findings demonstrate that flowering stage is the most critical growth stage, in fact, the units that received the highest amounts of water at flowering stage produce the largest yield (48.1q/ha with dose 363 mm and 34.9 q/ha with dose 230 mm).

One of the important observations at this trial is that the units that receive less than 50 mm at flowering stage have a critical impact on its grain yield. Furthermore, the units that received the highest amounts of water at flowering stage produce the highest number of spikes per m^2.

This high yield obtained using treated wastewater as supplementary irrigation source, compared with adjacent rainfed wheat field, which received 107 mm yielded almost zero tonnage. This result indicates the high value of the treated wastewater reuse as supplementary irrigation. If water is the limiting factor, and land is available, it appears more effective to use lower dose on large acreage. In fact, if the same amount of water (363 mm) which produced the highest yield, is applied at the rate of (230 mm), this will cover 1.58 ha which will produce 55.1 q/ha (based on the yield produced at a rate of 230 mm), and the WUE will increases from 132.4 to 151.8 g grain /m^3.

Salt Build-up

The other components that must be taken into consideration are the concentration of sodium and chloride, which are presented in high concentration in treated wastewater, as the accumulation of these salts lead to salinity problem on the long run. For example the soil chloride concentration before sowing was 0.28 g/kg, at the end of trial it became between 0.6-0.8 g/kg; the sodium was 0.3 g/kg it became between 0.5-0.6g/kg.

Nutrients Budget

In other investigation, tertiary treated wastewater is applied (using reed bed), so the quantities of NO_3 and P levels were low and did not meet the plant nutrition requirement with dose (200mm), and induced soil nitrate reduction. Therefore tertiary wastewater treatment could meet the environmental goals, but didn't match the crop nutrition requirement.

The high purification level of treated wastewater, and the installation of disc-filter upstream in the field, protects the mini-sprinklers system from clogging, but the disc-filter has to be washed frequently after each three applications.

Economic Benefit

The main aims of wastewater reuse for developing countries are to ensure a vital or in some cases alternative resource for food production. Wastewater reuse saves on the cost of fertilizers, which are needed for increasing the productivity at the farm level.

The analysis of total gain on fertilizers for the production of sweet pepper based on the content of nitrogen, potassium and phosphorus was calculated for plants irrigated with wastewater. It varied from 210 to 347 US dollars per hectare (Table 4). This could be considered as an incentive to farmer for reusing treated wastewater. Even though the development of sustainable water recycling schemes must include an understanding of the social and cultural aspect of water reuses.

Table 4. Fertilizers gain for growing sweet pepper irrigated with treated wastewater

		Fertilizer supply from treated wastewater (Kg/ha)			Fertilizer value (US dollars)
		Ammonium Nitrates	K Sulfate	MAP	
100%ETM	TWW	1238,03	132,94	159,12	300
	AT	839,29	120,84	100,20	210
120%ETM	TWW	1429,96	153,55	183,80	347
	AT	996,95	143,53	118,99	250

The economic analysis of the reuse of treated wastewater allows farmers to reduce the cost of the fertilizers inputs (Table 5). This could be a great incentive for the promotion on recycling treated wastewater in agriculture.

Table 5. Economic gains from treated wastewater (Euro/ha)

species	Geranium	Durum wheat	Bread wheat	Eggplant	Maize
Fertilizers inputs gains (Euro/ha)	456	780	680	776	350

Using 2410 m^3 per hectare for wheat production can save 30-35% of the nitrogen fertilizer, 10% of P fertilizer, and 70-82% of K fertilizer, of the whole plant exported nutrients and increase the farmer income.

CONCLUSIONS AND RECOMMENDATIONS

This study was a part of comprehensive project aimed to develop wastewater best management practices for irrigation of vegetable crops, flowers, and cereal's crops grown commonly by the farmers in the Agadir region. These studies show clearly the feasibility of the reuse of treated wastewater, if certain management practices are applied. We suggest developing a demonstration farm which will serve as a demonstration plots to show the farmers how to attain optimum yield and quality with minimum leaching of NO_3-N below the root zone.

Nutrient management is a pollution prevention achieved by developing a nutrient budget for the crop, applying nutrient at the proper time, applying the amount of nutrient necessary to produce a crop and considering the environmental hazard of the site. The response to the need to control leaching of nutrients and contamination of soil and water recommended several steps to reduce the risks of nitrogen pollution practices as well as reducing cost of supplied water. Within this framework, we are testing different water regime as well as alternation between saline water and treated wastewater to optimize nitrogen application and reduce the risk of groundwater nitrate pollution. As well as to determine the feasibility of supplemental irrigation to stabilize the bread wheat yield.

The conclusions resulting from these studies demonstrate the height value of the reuse of treated wastewater when appropriate practices are adopted, in fact Best practices should include:

- Crop Selection and Certification of Produce (Labelling)

Variations in absorption of certain chemicals by crops, makes crop selection a suitable strategy, in the absence of market forces, which discourage crop restriction.
Offering financial incentives i.e. labelling clean products, which will fetch higher prices, is also a possibility provided customers are willing to pay more and certification programs, which are costly processes, can be set up.

- Improving Irrigation Practices

Irrigation techniques, which wet only the roots and not the leafy part of vegetables, were suggested as good practice for minimizing risk of contamination. Bed and furrow irrigation, drip systems and any other technique applying water close to the root systems was suggested. There is a further advantage in that there will be less infiltration into groundwater. Rotating wastewater application over fields if this is possible is another means to limit over-fertilisation and pollution of groundwater. Avoiding irrigation with wastewater in the two weeks before harvest can minimize the risk from pathogen contamination of leafy vegetables, but this necessitates a fresh water source accessible to farmers, which is rarely possible in these peri-urban situations.

- Pollution risk mitigation should rely the following good practices:
    - ❖ It is important to establish with high precision the water balance in the soil plant system, by quantifying the inputs (rainfall, irrigation volume) and the outputs (crop uptakes, and evaporation)
    - ❖ Analyze the nutrient contents, in particular treated wastewater nitrogen. This will allow quantifying the amount of added nitrogen in the applied irrigation considering the yield level to be achieved in order to evaluate the nutrients uptakes.
    - ❖ Based on the soil analysis, consider the balance mineral nitrogen remaining in the soil.
    - ❖ The irrigation dose is an important factor that conditions the nitrate leaching. Therefore, in light sandy soils, it is recommended to reduce the amount of water applied and increase

the frequency. At this level it is recommended to consider the importance to optimize the rate of nitrogen and the irrigation water depth on the basis of crop water and nitrogen requirements for the different stages.

- ❖ Choose crops with high nitrogen uptake, and / or assure maximum soil crop cover.
- ❖ Mixing rich nitrogen waters and low nitrogen waters or alternate these two types of waters.

The knowledge of the amount and the form of the mineral nitrogen in the treated wastewater is of prime importance. In fact, depending on the adopted treatment process, this water would contain ammonium (lagoon) or nitrate (infiltration-percolation). It the first case, it is recommended to use nitrification inhibitors, and in the second case, two possibilities are to be considered: add a denitrification system at the plant level or mix the treated wastewater with a proportion of surface or underground water to reduce the level of nitrates.

It is also strongly recommended to establish a nitrogen mass balance, coupled with a water balance in order to protect the aquifer against nitrate contamination. The objectives are to keep the nitrate concentration in the water below 50 mg/l or assure 0% annual increment rate in the case the nitrate concentrations exceed 50 mg/l.

So, a particular attention must be focalized on the assessment of the treated wastewater composition and on periodic quality monitoring in order to guarantee a healthy use in irrigation. To reach this objective, some directives must be adopted including the choice of the treatment plant type, the minimization of the human exposure, the choice of crops, the choice of adapted irrigation systems and the setting up of the monitoring and surveillance system of the soils, water and agricultural products harvested.

It is clear that the notion of the risk "zero" is difficult to reach and doesn't justify himself always on the economic plan in our regions. Thus, it is important to adopt all techniques susceptible to reduce the potential risk to an acceptable level.

The various factors of risk must be converted in actions of attenuation and regulations associated to good wastewater reuse practices with respect in the same rigor that laws or instructions. The code of good practices of reuse, all as standards of quality, must be developed and adapted to take account of the specific local conditions.

From macro scale analysis point of view, we can recommend for Mediterranean countries (i) setting up demonstration and extension of the Best Management Practices for saline and treated wastewater under different cropping systems, (ii) generation of tools to guide and help policy and decision makers in elaborating strategies for non conventional or more exactly alternative water resources use in arid Mediterranean zones, (iii) reinforce the training of technicians, farmers in the all subjects related to water recycling (iv) coordination of the actions invested in these fields to avoid the dispersion observed now in different submitted and curing projects and (vi) standardization of the guidelines of wastewater, saline water and sewage sludge in Mediterranean countries.

Other targets will be political leadership at the regional and national level, and influential people, for whom a sensitization program should established, through the organization of seminars and workshops. The results established in these studies should be presented and discussed.

The assessment of leading experiments in terms of processing and re-using waste water remains mitigated. With assistance from international organizations, Morocco launched several projects with significant results. The failure of certain processing projects because of the inadequacy of the process to the socio-economic context of the concerned regions made it possible to better understand the problem of waste water.

In spite of the acquired experience, used water processing projects achieve only a timid progress. The principal obstacle remains the financing, the awareness of the public authorities and the lack of a national policy in the field of management of the waste water with the purpose to protect water resources.

Currently, certain stations reprocess used water by maintaining the treatment performances defined in their system. The follow-up of the physicochemical and microbiological parameters is regularly assured by scientific supervision teams. Treated waste water is currently re-used in agriculture only on an experimental basis or is limited in certain cases to the farmers on grounds located near the station when this water is evacuated in nature as it is the case of the rural commune of Drarga.

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