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The lagunage for the purification of waste water in the Sahara: an approach integrated into the environmental conditions

N. M. Chabaca[1] , A. Kettab[2] , M. Nakib[2] , S. Karef[2], S. Benziada[2], S. Benmamar[2], W. Boumalek[2], H. Bouanani[2], Y. Djillali[2]

[1] National Superior Agronomic School Algiers Algeria, Avenue Pasteur Hassan Badi 16200 El Harrach Algiers
[2] Research laboratory in Sciences of Water (LRS-EAU) Polytechnic national school, 10 Avenue HassenBadi, B.P. N°182, El Harrach, 16000, Algiers, Algéria

*Corresponding author: chabacam@yahoo.fr; Mobile: + 213 7 78 51 94 71

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ABSTRACT/RESUME

Abstract: *The water resources currently exploited in the Algerian Sahara, are in majority underground. . Contrary to the northern zone where the discharge system of water of the rivers is done towards the sea, carrying with them waste water purified or not; in the South, the rivers at the time of the risings, run towards the interior of the grounds, involving with them waste water, contaminating the sebkhas and the tablecloths. It is the case in the valley of M'zab and the zone of Ouargla, wedged mediums where the rejections pollute the ground water directly. The treatment of waste water became a requirement and a social and environmental stake impossible to circumvent. The process of treatment by lagunage is used in the purification plants of the towns of Ghardaïa and Ouargla It is ecological insofar as it does not use any chemicals to treat waste water and to evacuate them without risk towards the receiving natural environment. Fragile environmental balance and the ecosystem of the Saharianunit, must be safeguarded and for this reason it is important to remove the harmful effects in residential areas; to protect the receiving medium and the ground water; to make possible the re-use of waste water purified at agricultural ends.*

I. Introduction

The conventional water resources of the countries of southern bank of the Mediterranean, from which Algeria forms part, are limited. Algeria has only 500 m^3 out of water per capita of inhabitant whereas the World Bank recommends a minimum of 1000 m^3/hab/year). Algeria is a semi-arid country, and even arid and its water resources are weak, irregular, and localized in the coastal strip **[1]**. It east is a country with contrast, with a surface of 2,381,740 km² (desert 80%) and 38 million inhabitants including more than 80% concentrates in the Northern fringe. Pluviometry is of 1400 mm/year in the extreme North-East, 800 to 900 mm in the North-eastern zone, 500 to 600 mm in the Northern Center and around 300 mm in Western North, 100 mm/year and less, in the Sahara. Evapotranspiration (ETP) is of 1000 to 1400 mm/year in the coastal areas and the high plains, 1600 mm in the Saharian Atlas, between 2000 and 3000 mm/year and some time higher than 3000 mm/year, in the Sahara. The constraints of the climate, the population growth, and the economic

and social transformations are at the origin of a demand for unceasingly increasing water. That involves also a development of the water pollution which in its turn if it is not controlled can pollute the environment and deteriorate subterranean water. Vis-a-vis these requests, the water resources are rare and insufficient. Annual precipitations are about 12, 3 billion m^3; the dams are 75, storing 6 billion m^3, for a storage capacity of 7, 5 billion m^3, and the underground have a storage capacity of 2 billion and are exploited to 90%. The underground water in the Sahara, CI (continental Intercalaire) and CT (complex terminal) covering Algeria Tunisia and Lybia are evaluated to 6.1013 m^3. Visa-vis these constraints, which possible recourses?A policy of mobilization and use of conventional water (underground and of surface) of nonconventional water (desalination of sea water, water brackish, waste water) was installation recently.To satisfy the requirements out of water for the country, one of the solutions would be to use water of marginal quality in agriculture and to hold water of good quality to the drinking water supply. With the access to the cleansing (84%), important volumes of purified waste water are rejected each year.Currently, rejected polluted water, borders the 900 million cubic meter (15% of surface waters stored in the dams) thisvolume will exceed 1,5 billion cubic meter by 2020.. In Saharan medium, water is available, but in its large majority very slightly renewable, vulnerable to the pollution and in particular to the phenomenon of salinisation. The water resources in these areas are often badly managed and impose a rational and integrated management and this, from a point of view of durability. Fragile environmental balance and the ecosystem of this unit must be safeguarded and for this reason it is important to remove the harmful effects in residential area; to protect the receiving medium and the ground water; to make possible the re-use of waste water purified at ends of irrigation **[2].** Agriculture in this medium represents the main activity, whose occupation of the ground is divided into three stages: phoéniciculture; fruit trees; market gardening's and fodder in guides. With the extension of surfaces, the sector of agriculture offers great developmental perspectives**[3].** In the south of the country, contrary to north, the establishment of demanding STWW (station of treatement of waste water) of the lagunage type ventilated or natural in surface do not pose a problem.

II. Material and methods

The Sahara represents more than 80% of the surface of Algeria. The water resources of which it lays out are entirely underground. The zones of life and economic activities of the Sahara are in a wedged medium where the rejections will unrelentingly join the undergroundwater sources of life, as well as the chotts and Sebkhas. More than in North, their protection is vital. Currently, the Sahara roughly produces 30% of the waste water rejections (22% in 2000) **[4].** The purification of the rejections must relate to all the zones of life. For this reason the natural or ventilated lagunage, is a practice of purification economically viable, more accessible than for the stations with activated sludge. Maintenance and entretien are more rustic there, consumption in less greedy energy.M'Zab (surface of 84.660 km^2, population of 396,452 inhabitants of which 44.75% occupy 4.77% of the surface; a pluviometry of 75 mm/an, a ETP of 3110 mm/an) and Ouargla (surface of 163,323 km^2; population of 615,543 inhabitants; a pluviometry of 36 mm/an; a ETP of 3213 mm/an) is located respectively at 600 km and 850 km at the south of Algiers, in the septentrional Sahara (figue 1).
In the wilaya of Ghardaïa, the agricultural sector is limited, it is with phoénicicole vocation. On the 8,466,012 ha of the wilaya, 1,370,911 ha are assigned to agriculture and the useful agricultural surface (USA) is evaluated to 32,745 ha.

Because of weak precipitations, the exploited USA is limited to the only surfaces being given a water resource (drillings, well), the remainder consists of pasturages and course with 1,337,994 ha and of unproductive grounds of the farms with 172 ha. The sector of agriculture is characterized by two operating systems:

- Oasien of the old palm plantation
- Development, of zones except oasis

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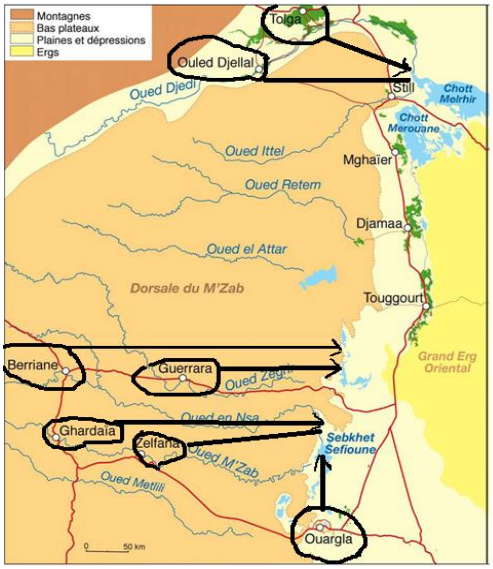


Figue 1.*Situation of Ghardaïa and Ouargla*

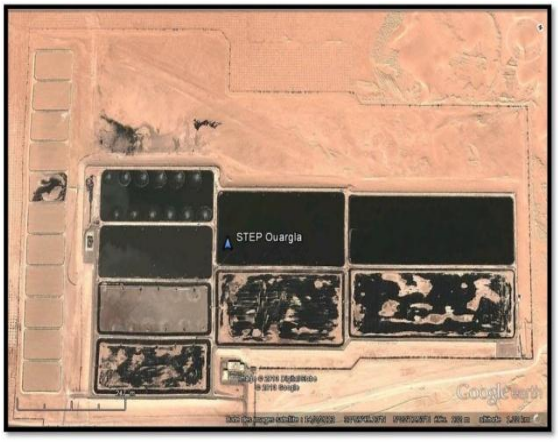
With the extension of surfaces, the sector of agriculture offers great developmental perspectives**[5].**The purification of waste water by lagunage ventilated of Ghardaïabrought into service in 2012 is located in the commune of El Atteuf at the downstream of the valley of M'Zab. Ithas a capacity for treatment of331,700éq/hab and covers a surface of 79 ha, with 10 beds of drying, 16 basins divided into 2 levels (figue 2). The daily medium flow with rated capacity is of 46,400 m^3/j. (table 1).

Figue 2: *STWW of Ghardaïa*

Table 1.*Evolution of the production of waste water in the valley of M'Zab**[6]).***

Waste water	Unit	1996	2000	2010	2020	2030
Rate of connection	%	85 %	85 %	90 %	95 %	100 %
éq/habconnected	u	108 163	120 870	172 530	240 920	331 700
Medium flows	m^3/d	15 143	16 922	24 154	33 729	46 438
% rated capacity	%	33 %	36 %	52 %	73 %	100 %

In the wilaya of Ouargla, the agricultural sector is limited; it is especially with phoénicicole vocation. On 16,323,300 ha that account the wilaya of Ouargla, 4,940,000 ha are assigned to the agriculture including 38,400 of USA divided into 35,300 ha in irrigated and 3100 ha in dryness.The purification of waste water by lagunage ventilated of Ouargla brought into service in 2009 will have a capacity for treatment of400,000 éq/hab. at the horizon of 2030. It covers a surface of 80 ha, with 11 beds of drying, 8 basins divided into 3 levels (figue 3). The daily medium flow was of 57,000 m^3/j in 2015 and will be of 74,027m^3/j by 2030 (table 2).



Figue 3.*STWW of Ouargla*

The level of purification retained will allow, on the one hand, the rejection about the receiving middle via the main drain and on the other hand a restrictive irrigation (level B according to

WHO:World Health Organization).The natural lagunage present of multiple advantages: rustic and economic compared to a traditional purification.Currently these two stations treat domestic waste water produced by the population. The physico-chemical analyzes carried out concern: suspended matter (SM);the chemical demand for oxygen (CDO); the biological request oxygenates some($BROS_5$); determination of the pH; determination of dissolved oxygen (O2);

Table 2: *hydraulic and polluting loads at the various horizons*

Waste water	Units	2005	2015	2030
Rate of connection	%	70%	95%	100%
Connected EH	u	142	260	393
		937	102	592
Total flow	m^3/d	40 906	56 997	74 027
% ratedcapacity	%	55%	77%	100%

determination of electric conductivity ; salinity and the temperature; Determination of (NH_4+, NO_3, NO_2-, PO_4-, NR_{total}).

III. Results

The median values of the measured parameters and the standards necessary for the irrigation are presented in table 3. In the same table on a purely comparative basis the values of the parameters measured in the STEP of Boumerdes by activated sludge appear.

The average contents of the parameters analyzed on the level of the three STWW meet the required standards, it is the case of: T (°C), pH, NO_3, NO_2^- and parameters bacteriological (coliformes total and coliformes fecal). Observed a higher rate of salinity for the purified water of the STWW of Ouargla compared to that of Ghardaïa. Thus, one can classify this water in the category B1 (CF <105) according to the revised microbiological standards of WHO (the World Health Organization) with an irrigation restricted for the following cultures: cereals, industrial crops, fodder, pastures and drills. On the other hand, a study of the content of heavy metals of this water is desirable in the laboratory of each STWW in order to eliminate the risks which result from it.

Table 3.*Median values of the measured parameters of the STEP of Ouargla, Ghardaïa and Boumerdes and standards of interpretation for the irrigation* ***[7] [8].***

Parameter	Effluent treated Ouargla (Average)	Effluent treated Ghardaïa (average)	Effluent treated Boumerde (Average)	Water quality standard of irrigation
T (°C)	17.38	22.79	19.93	30
pH	8.05	8.27	7.24	6.5 à 8.5
EC (ms/cm)	12.85	3.83		< 3
Salinité (g/l)	7.38	2.19		Pas de norme
O_2dissolved (mg/l)	6.06	6.22		< 5
DBO_5 (mg/l)	33.76	31	5.99	< 30
DCO (mg/l)	124.42	204.7	37.98	< 90
MES (mg/l)	84.4	73.47	10.64	< 30
NT (mg/l)	55.22	33.47	1.97	< 50
NH_4^+ (mg/l)	29.86	24.05	0.51	< 2
NO_2^- (mg/l)	0.36	0.3	0.07	< 1
NO_3^- (mg/l)	2.88	0.41	9.09	< 30
PT (mg/l)	3.91	3.8	1.86	< 0.94
CT (N/100ml)	26 666.7	42766.7		*** < 50 000
CF (N/100ml)	3033.33	3966.67		*** < 20 000

Energy STEP with lagunage compared to a STWW with activated sludge favor **[4].**

Cost of the installation for each type (table 4)

STWWBoumerdes (activated sludge) approximately 75,000 EQ/HAB: 1, 198,804 485.55 DA TTC (**Any inclusive of tax)** °.STWWOuargla (lagunage natural) approximately 216,500 EH/HAB: 654,424,127.18 DA TTC. STWW Ghardaia (lagunage natural) approximately 300,000EH/HAB. 2,808,755,922.02 DA TTC

Table 4. *Consumption of electrical energy of the month of November 2016*

wilaya	Purification Station	Capacity: M^3/jEQ/hab	PMD en Kw	Energy Activate in Kwh	Energy Reactivates in Kvarh	PMA en Kw	Report /ratio Q/P	Assembling invoice in DA of the month (n-1)	Rate of consumption Kwh/m^3
Boumerdes	**With activated sludge Boumerdes**	15,000 m^3/d 75,000 Eq /Hab	500	159 951	124 887	419	0,79	597 499,87	**0,38**
Ouargla	**Ventilated Lagunage Ouargla**	56,997 m^3/d 260 102 Eq /Hab	750	187 392	92 943	534	49,60	525 272,33	**0,23**
Ghardaia	**Natural Lagunage of Kef Eddoukhen**	46,400 m^3/d 331,700 Eq /Hab	50	2 704	5 730	7	211,91	16 664,32	**0,01**

Environmental impact

The STWW can have several impacts in particular (table 5)

Table 5. *Environmental impacts of the three models of STWW*

wilaya	Purification Station	Capacity : M^3/d EQ/hab	Impact Environmental
Boumerdes	**With activated sludgeBoumerdes**	15,000 m^3/d 75,000 Eq /Hab	Protection of the littoral through the protection of Tataregwadi and re-use of purified waste water
Ouargla	**Ventilated LagunageOuargla**	56,997 m^3/d 260,102 Eq /Hab	Protection of the wetland of SebkhetSefioune and re-use of purified waste water
Ghardaia	**Natural Lagunage Kef Eddoukhen**	46,400 m^3/d 331,700 Eq /Hab	Protection of Wadi Me zab and the ground water. Possibly introduction of the re-use of waste water purified to agricultural ends

IV. Discussion and conclusion

Total projections at horizon 2020 made it possible to quantify a deficit of approximately 0, 9 billion m^3 of water in Algeria of North **[9].** The waste water layer in Algeria was estimated at 750 million m^3 in 2010, it will exceed 1, 5 billion m^3 by 2020 **[10].** The re-use of waste water purified for agriculture would make it possible to save nearly 0,9 billion m^3 water is 30% of the volume intended for the drinking water adduction (DWA) and industry **[2].** Vis-a-vis a chronic hydrous deficit, the treated waste water represents a renewable water resource impossible to circumvent with the other nonconventional water resources (desalination of sea water, brackish water…) that it will be necessary to take into account in the future in the Saharan zones, within sight of the difficult climatic conditions, of the urbanization which gallop in the oases (wedged mediums) and of the risks of attack in the medium. This re-use does not represent only one competitive economic option, but also of many welfare benefits and environmental. This valorization must be placed within the framework of the integrated management of the water resources, by working out a national strategy of the valorization of treated waste water. The results obtained, show that waste water of the purification plants of Ghardaïa and Ouargla, whose treatment is done by lagunage natural are of poor quality and require a tertiary treatment to use them in the agricultural domain (the irrigation) without any risk. Storage in basins is necessary to better refine this water. Following their wealth in fertilizing elements and oligoéléments, water use purified stimulate the microbiological activity of ground **[11],** supporting the mineralization of the organic carbon of the ground, when the conditions are favorable, which involves a fall of the rate of MO in the ground **[12].** These stations were conceived to achieve the following goals: To remove the harmful effects in residential area; to protect the receiving medium and the ground water; to make possible the re-use of waste water purified at ends of irrigation. It should be noted that this use must be made optimal and so that it is thus, the following conditions must be filled: to adapt the systems of irrigation to water quality employed; to optimize the contribution of water and to adjust the fertilization with the needs for the cultures. Palm trees represent the principal culture in these zones, the palm plantation is characterized by a great resistance to water of bad quality. In the south of the country, contrary to north, the establishment of STWW of the lagunage type ventilated or natural, demanding in surface do not pose a problem.Purified water of the STWW of Ghardaïa, will be intended to irrigate aperimeter of 500 ha arable lands, located on left bank of the wadi M' Zab at the downstream of the station. That of Ouargla can feed the zones of development, as well as the old palm plantations. The renewable energy resources (solar and wind), constitute a considerable factor for a development guaranteed and supported agricultural activities. They will ensure the energy supply necessary to the operation of the stations oflagunage, like those of the pumping stations intended for the irrigation and will make it possible to guarantee a real energy independence. The irrigation using treated waste water is a means economic to reduce the rejections in the environment. The effluents of the purification station contain a great quantity of nutrients usable for the plants, thus reducing the use of artificial fertilizers and their production. The re-use of treated waste water has costs limited compared to the other techniques developed to get fresh water. The production of treated waste water costs less expensive than the major water provision underground, than the importation of water and than desalination. It limits the shortages by improving the availability of the resources in particular in the event of dryness. The use of treated waste water makes it possible to stop the limits of the production of foodstuffs related to the lack of water, contributes thus to world food safety.

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