

EVALUATION OF CULTIVATED LAND REQUIRED FOR TERTIARY TREATMENT OF SECONDARY EFFLUENT FROM THE EAST WWTP OF TIZI-OUZOU (ALGERIA)

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Abstract

Our study focuses on the physical chemical and biological effluent characterization and evaluation of cultivated soil surfaces (viticulture and citrus) for tertiary treatment of nitrogen, phosphorus and potassium content in the secondary effluent of the sewage treatment station (STEP) east of the city of Tizi-Ouzou Algeria.

The results of physicochemical analyzes, performed over a period of three years, show that the treated effluent, has a slightly alkalinity ($\text{pH} = 7.52$), annual average concentrations of 20.15 mg/l total nitrogen from 11.30 mg/l total phosphorus and 19.35mg/l of total potassium. The determination of the parameters measured pollution indicators gives average: $\text{BOD}_5 = 28.32$ mg/l, $\text{COD} = 44.50$ mg/l, $\text{MES} = 14.20$ mg/l. The concentrations of heavy metals in sludge from these waters are: $\text{Cr} = 74.2$ mg kg DM, $\text{Cu} = 115$ mg/Kg DM, $\text{Ni} = 10.5$ mg/kg DM, $\text{Pb} = 6.8$ mg/Kg DM and $\text{Zn} = 400$ mg/kg DM. They are lower than the accepted standards in the agricultural use of these effluents. The concentrations of nitrogen, phosphorus and potassium in the sludge are 11.75 g/kg DM, 8.18 g/kg DM respectively, and 16.06 g/Kg DM g/kg DM. The results of the laboratory tests also show the total absence of parasites or their eggs may limit agricultural reuse of the effluent.

The area planted for tertiary treatment obtained experimentally for vineyards and citrus cultivation, applied to the treated effluent of the STEP East Tizi-Ouzou with a capacity of 120,000 population equivalents are measured at 909 ha to 983 ha. The nitrogen inputs, phosphorus and potassium in the annual volume of irrigation are respectively 148.20 kg / ha / year, 81.69 kg / ha / year and 139.88 kg/ha / year for viticulture and 134 58 kg / ha / year, 75.47 kg / ha / year and 129.24 kg / ha / year for citrus. The respective averages nutrient equivalent inhabitants by hectare by year are respectively 132 EH / ha / year and 122 EH/ha / year for viticulture and citrus. The annual flows of 132.385 tonnes of total nitrogen, total phosphorus 74.241 tons and 127.129 tons of potassium with a year cumulation from 6 570 000 m³ of water.

Keywords: treated wastes, nutriment, valorization, filter, agrumiculture, viticulture

INTRODUCTION

Following the failure and irregular rainfall gradient in Algeria, it is difficult to envisage a food security strategy especially without a real and adequate program of mobilization and management of conventional and unconventional water resources. It is indeed necessary to satisfy global water needs of the population that currently amount to about 1,700 m³ / ha / year and thus a reduction spectrum of hydro-sensitivity for the country (Condom, 2012).

Before the pressing needs related to climate and particularly high values of evaporation and evapotranspiration and overall water that needs continues to grow, it is impossible to settle for conventional natural resources exclusively, approaching their limits quantitative and qualitative. The use of non-conventional clean and treated water that represent a reliable and well localized resource becomes an attractive and compelling alternative to multiple titles (Vasel, 2007; AQUAREC Project, 2006; Sala and Serra, 2004 Pescod, 1992).

In Algeria, the volume of domestic wastewater discharged is estimated at nearly 800 million m³ / year, it represents significant amounts and recurring that the country cannot ignore. Moreover, paradoxically, nitrogen and phosphorus are firstly essential nutrients in the soil compartment to the

intensification of agricultural yields, on the other hand considered undesirable for environmentalists in the water compartment where their presence in excess is detrimental to the environment and public health.

However, in recent decades, the growing trend of nitrogen and phosphate pollution, has led the authorities to strengthen the regulatory requirements for these elements, by appropriate treatment leading to uphold the quality objectives of releases to environmental compartments receivers. In order not to violate the natural self-purification processes of the different receiving environments, it is necessary to optimize the inputs and outputs of nutrients in these compartments as essential as fragile, depending on the final destination of the treated effluent (Mohammad and Mazareh, 2003; Van der Hoek et al, 2002).

In addition, this modest study is a contribution to the quality requirements of the receiving waters. It seeks to dimension the planted natural surfaces that could serve as the receiving environment, in order not to exceed their self-purification potential and protect the natural cycles of these nutrients.

OBJECTIVE OF THE STUDY

To meet the quality objectives for receiving waters and to optimize the progressive mineralization of these nutrients to benefit crops up, the quantification of water flows, nitrogen, phosphorus and potassium from urban effluent treated Is treatment plant in the city of Tizi-Ouzou and sizing of natural surfaces planted hectare (ha) and equivalent persons by hectare (EH / ha), can meet a number of concerns, namely:

1. Free extensive additional purification;
2. Reduction of tertiary treatment costs STEP;
3. protecting natural environments receivers;
4. extra water;
5. save "pure" resources of good quality to the noblest needs;
6. reduced production and use of mineral fertilizers;
7. organic fertilization progressive mineralization;
8. Improved physicochemical and textural properties of soils;
9. Development of a peri-urban agriculture;
10. economic benefits for farmers;
11. organic carbon input to soil and crops (Metahri, 2008).

Tertiary treatment of secondary effluent

The treatment consists in infiltrate and percolate secondary effluent STEP through a cultivated soil (and reproduce the natural systems of extensive purification with macrophytes or constructed wetlands). The remaining suspended solids will be stopped at the surface of filtering massive, the microorganisms are removed by adsorption and microbial biodegradation, protozoa and helminths are retained from the first centimeters of the soil. Nitrogen and phosphorus ore will be absorbed by plants (Lazarova, 2005; Feigin et al, 1981). However, it should comply with national or international standards for crop irrigation with treated wastewater, including the health component that is not covered in this part of our effluent.

Physicochemical characteristics of raw wastewater and treated in the East STEP of Tizi-Ouzou

The physicochemical characteristics of pollution parameters in Table 1 represent the averages and standard deviations of three years of raw and treated wastewater from the treatment plant east of the city of Tizi-Ouzou.

Table 1: physicochemical characteristics of raw wastewater and treated in the STEP east of Tizi-Ouzou.

parameters analyzed	Raw wastewater		Treated wastewater	
	Entry values	average Standard deviation	Average output values	Standard deviation
pH	7.44	1,81	7.52	1,17
Temperature (°C)	21.72	1,53	21.12	2,21
Turbidity (FTU)	262.86	26,44	15.53	25,27
MES (mg / l)	288.06	24,22	14.20	22,13
DCO (mg O ₂ / l)	640	6,84	44.50	7,44
DBO ₅ (mg O ₂ / l)	395	3,14	28.32	3,52
N-NH ₄ ⁺ (mg / l)	29.83	27,32	1.12	24,12
N-NO ₂ ⁻ (mg / l)	0.089	2,15	0.776	1,17
N-NO ₃ ⁻ (mg / l)	1.37	4,28	18.26	3,38
Total N (mg/l)	31.28	23,15	20.15	19,42
Total P (mg / l)	13.25	15,34	11.30	11,18
Total K (mg / l)	21,55	14,16	19.35	8,93

Table 1 shows that the treated effluent has addressed the physicochemical characteristics conform to traditional STEPS, which do not have tertiary treatment for removal of nitrogen and phosphorus and suitable for agricultural reuse.

Indeed, levels of nutrients items (nitrogen, phosphorus and potassium) wastewater after secondary treatment range from 20 to 60 mg / l for nitrogen (FAO, 2003), 6 to 15 mg / l of phosphorus and 10 to 40 for potassium (Fonseca, 2007) interested in several titles farmers.

The concentrations of nitrogen, phosphorus and potassium in sewage sludge from the East STEP of Tizi-Ouzou shown in Table 2.

Table 2: Nutrient Concentrations sludge WWTP

parameters	N	Standard deviation	P	Standard deviation	K	Standard deviation
Supplied through sludge (g / kg DM)	11,75	4,28	8,18	3,12	16,06	4,15

Similarly, the concentrations of trace elements of sludge from these waters are: Cr = 74.2 mg / kg MS, Cu = 115 mg / Kg, DM, Ni = 10.5 mg / kg MS; Pb = 6.8 mg / Kg DM and Zn = 400 mg / Kg DM; and have therefore no limit reuse of these effluents in agricultural irrigation (WHO, 2006).

Agricultural use of domestic secondary effluents

Soil and rivers, were always the natural receptacle of pollution caused by human activity. Advanced techniques currently used in wastewater treatment plants of urban waste water, only a self optimizing natural treatment that is exerted in both environments. (Guilloteau, 1992).

Among the methods of treatment, sewage systems, floor were extensively studied. They are used for elimination of the order of 70 to 80% nitrogen, brought of phosphorus and potassium

The idea to value these resources came first producers of these effluents wishing eliminate at least cost, then by farmers who are attracted to water and fertilizer elements contained in these releases as well as their low cost or they are free (WHO, 2006).

In this specific case, irrigation with treated wastewater is a kind of fertigation, that is to say the combined application of water and fertilizers using the irrigation system (Soudi, 2009).

This irrigation method allows a fractional contribution or continuous low dose of organic fertilizer; profits do not reside only in the preservation of the environment and resource, but also in the nature of the wastewater (Fonseca et al, 2005)

In addition to fertilizing elements these effluents are rich in organic matter and trace elements (iron, copper, manganese, zinc, etc.), the concentrations encountered are beneficial for crops, and can significantly increase the yield.

In fact, a treated water blade of 100 mm to be (1000 m³ / ha) bring crop in a mode equivalent to fertigation 40 Kg mineral and Mineralizable nitrogen per ha, 11 kg of available phosphorus / ha and 28 kg potassium / ha. (Soudi, Kerby and Choukrallah, 2000).

In the case of our STEP the same sheet of water treated would bring 20.15 kg / ha of nitrogen, 11.30 kg / ha of phosphorus and 19.35 kg / ha of potassium, which are close to the recited values.

Recycling of treated wastewater in agriculture

Reuse is a voluntary and planned action aimed at the treatment and use of additional amounts of nutrients and water for different uses to fill the water deficit (Boutin, 2009).

The reuse of wastewater for irrigation is particularly interesting in countries with limited conventional water resources with a long dry season and where competition with drinking water is very marked (Rotardt, 2011; Aquerec Project, 2006).

In these countries the irrigation of crops or green spaces is therefore the way forward for the reuse of treated urban wastewater in the short and medium terms.

The reuse of treated effluent is used for new users from the initial users. The new use generally requires a water treatment to bring them to a satisfactory and quality suitable for the new intended use

The agricultural use of treated wastewater is a common practice and regulated in various countries (AQUEREC Project, 2006; Lazarova, 1998; and Mohammad Mazareh, 2003; Pescod, 1992). For example, in Florida and California (USA), volume 340 000 m³ / d and 570,000 m³ / d of wastewater reuse in agriculture were already in 1995. The experience of Mexico City seems to be the most important project of wastewater reuse globally 4 million to 25 million m³ / d that are reused for irrigation (Jemenez-Cisneros and Chavez-Mejia, 1997).

We may also mention the countries of the near and middle east such as Egypt that uses 550 000m³ / d, Kuwait with 140 000m³ / d, Saudi Arabia with 600 000m³ / d, Syria with 1000 000m³ / d and United Arab Emirates, with a volume of 500 000 m³ / d (FAO AQUASTAT 1998).). Besides this recycling should respond positively to the request of crops without affecting the receiving waters (Van der Hoek et al, 2002).

Local Inset

Sebaou the valley is the outlet and piedmonts of the watershed Algiers coded (02) with a total area of 2,900 km², which receives an average annual rainfall of 780 mm with an average potential evapotranspiration of 600 mm / year. Local agriculture is mainly directed to the vegetables, wine and citrus cultivation; types of irrigation is practiced by gravitational ascending, sprinkler and finally by the micro irrigation begins to generalize recent years (PPDRI, 2007). Valley Sebaou means is made of light-textured soils (sandy) Balanced (sandy loam or sandy clay), formed during the Quaternary alluvial deposits.

The French taxonomy classifies as little evolved alluvial soil intake (Saadi 1970; Metahri, 1991) with an average permeability; Hence the recommendation of localized irrigation.

The WWTP Candle Bridge is located 6 km east of the city of Tizi-Ouzou. It treats wastewater from the east part of the town and the neighboring villages of the town of Tizi-Ouzou. Raw sewage coming from a unitary network that drains the sewage (black water), household (gray water) and runoff from the city of Tizi-Ouzou, where a slight dilution of physicochemical parameters during periods of high water.

The effluent studied consists of secondary water treatment plant east of Tizi-Ouzou, whose characteristics are given in Table 3.

Table 3: Technical specifications of the STEP East Tizi-Ouzou (NAO, 2003).

Designation	values
Network Type	unitary
Nature of raw water	domestic
Nature of raw water	120 000 EH
hydraulic load	18 000 m ³ /j
Daily flow during dry weather	750 m ³ /h
Mean daily discharge	1620m ³ /h
Dry weather peak flow	2250m ³ /h
In wet weather peak flow	2250m ³ /h
pollutant load BOD₅	6500 kg/j
daily flow	360 mg/l
average concentration	8400 kg/j
MES	466mg/j
daily flow	
average concentration	

For the treatment of the results we have considered the nominal flow rate of the STEP pending the audits of actual flow rates are finalized

Crop needs in terms of water, nitrogen, phosphorus and potassium for Sebaou Valley

In Algeria and in Tizi-Ouzou in particular nitrogen requirements, phosphorus and potassium crop for intensive agriculture in the valley Sebaou means are defined in Table 4 and calculated on the basis of the average potential soil fertility in place.

In addition the annual water deficit remains large, hence the need for artificial water supply to fill this deficiency that is over 600 mm / year at the Sebaou Valley (ANRHTO 2010).

Table 4: nitrogen requirements, phosphorus and potassium in kilograms per hectare per year of the crops grown in the valley Sebaou (DSATO 2010).

Species	Nitrogen (Kg / ha / year)	Phosphorus (Kg / ha / year)	Potassium (Kg / ha / year)
Viticulture	130	100	120
citrus	220	160	200

RESULTS AND DISCUSSION

Average physicochemical parameter values of the treated effluent were followed for a period of three years, they are represented in Table 1. Nutrient inputs of the treated effluent of the WWTP tailored for crop nitrogen, phosphorus and potassium applied to soils in the valley Sebaou means are supplied in Table 4.

Outcomes treatment has been made on the basis of the nominal flow of said station pending the finalization of the actual flow calculation tests for possible implementation results. Assessment calculations of nitrogen inputs, phosphorus and potassium, as well as irrigable areas with sewage treated in this STEP, are made on the basis of population connected to the sewerage system of the said STEP which is 120,000 population equivalent (pe), with a daily discharge of 150 liters per capita per day.

Assessment of nutrient intake and planted areas from the treated effluent

Calculations will be made from the average data of the water balance of the sequence 2000 to 2011 Table 5 for the vegetative period of our cultures, averages in Table 1 on concentrations of nitrogen, phosphorus and potassium and averages table 4, corresponding to phosphorus nitrogen and potassium requirements of crops per hectare per year for the average Sebaou valley Tizi-Ouzou. To optimize the input and output of these nutrients in the receiving environment, we introduced the crop coefficient (Kc), also called coefficient of water consumption, specific to each plant species and according to the vegetative stages of culture in place.

We calculated the overall nitrogen inputs, phosphorus and potassium that are valued at 132.385 tons / year, respectively, 74.241 tons / year and 127.129 tons / year, we evaluated the contribution of these nutrients by the annual volume of irrigation every culture and we estimated planted areas for tertiary treatment of secondary effluent of said STEP, table 5 and 6.

To satisfy the overall needs crop up, especially in times of high demand, storage and mobilization pelvis is indicated for optimal contribution of the secondary effluent of the WWTP.

Table 5: Calculation of nutrient intake and the areas planted with treated effluent

parameters	Marc	Apri	May	June	July	August	Septem	Octob	Totals
P (mm)	110,2	92	52,2	11,5	4,3	8,8	41,88	67,6	388,48
ETP (mm)	68	98	137	154	174	159	120	79	989,00
Soil resources 100 mm	100	94	9,2	<<<	<<<	<<<	<<<	<<<	203,2
ETR (mm)	68	98	137	20,7	4,3	8,8	41,88	67,6	446,28
Rainfall deficit (mm)	<<<	<<<	- 75,6	- 142,5	- 169,7	-150,2	-78,12	-11,4	627,52
ETM means Vigne (mm)	722,93								
Citrus average ETM (mm)	667,93								

Table 6: Calculation of the balance sheet of fertilization of crops and irrigated area

Parameters	Viticulture			Citrus		
	N	P	K	N	P	K
Needs fertilizers (kg / ha)	130	100	120	220	160	200
	Average (NPK) 166,66			Average 193,33		
Contributions by the EUT (kg / ha)	148,20	81,69	139,88	134,58	75,47	129,24
	Average (NPK) 112,49			Average (NPK) 133,09		
Contributions by the EUT (% of requirements)	114	81,69	107,6	61,17	47,16	64,62
Observation	Dilution	Sup Contribution	Dilution	Sup Contribution	Sup Contribution	Sup Contribution
Contributions by TME equivalent inhabitants per hectare per year (EH / ha / year)	134,33	132,04	132,03	121,98	121,98	121,99
	Average 132			Average 122		
Estimation of planted areas necessary for tertiary treatment of secondary effluent of the WWTP (ha)	Average 909			Average 983		

To balance the contributions rate of the nitrogen station, phosphorus and potassium specific treatments to correct this discrepancy should be considered upstream or downstream of the purification process, otherwise to optimize the inputs and the outputs of nutrients in the soil compartment, it is recommended that a slight dilution for viticulture.

Furthermore, for citrus additional nutrient intake could be considered by a spreading of sewage sludge that STEP to address this deficiency.

This land application could be estimated from Table 2 and additional contributions means of nitrogen, phosphorus and potassium considered for citrus in Table 5 and 6. The calculations are given in Table 7.

Table 7: Calculation of adjustments nutrients from the sludge of the WWTP

parameters	N	P	K
Nutrient sludge concentration (g / kg DM)	11,75	8,18	16,06
	Average 11,99		
Average nutrient requirements for citrus in Kg / ha (Table 4)	193,33		
Nutrient intake by means EUT for citrus (Kg / ha) (Table 5)	133,09		
Nutrient deficiency to be corrected by a spreading of sludge WWTP (Kg / ha)	60,24		
Amount of sludge in Kg / ha required	5024,18		
Sludge quantity in tonnes / ha required	5,02		

CONCLUSION

This study allowed us to firstly, to evaluate the physical and chemical quality parameters of the secondary effluent of the WWTP east of Tizi-Ouzou for agricultural reuse.

On the other hand, it has also allowed us to determine the acreage same time allowing a tertiary treatment of nitrogen, phosphorus and potassium, to optimize nutrient inputs and outputs in different compartments to ensure quality objectives and balance of natural environments receivers to not exceed their self-strainer power.

The contributions of the secondary effluent correspond to an annual flow of 132.385 tonnes of total nitrogen, 74.241 tons of total phosphorus, total 127.129 tons of potassium and an annual total of 6.57 million m³ of water.

The concentrations of nitrogen, phosphorus and potassium in sewage sludge are respectively 11.75 g / kg DM, 8.18 g / kg DM and 16.06 g / Kg DM g / Kg DM

The contributions of treated wastewater nitrogen, phosphorus and potassium annual irrigation volume deducted from the balance of calculating the respective contributions of 148.20 kg / ha, 81.69 Kg / ha, 139.88 kg / ha for viticulture and 134.58 kg / ha, 75.47 Kg / ha, 129.24 kg / ha for citrus.

The respective averages nutrient equivalent inhabitants per hectare per year are respectively 132 EH / ha / year and 122 EH / ha / year for viticulture and citrus.

The respective current values of the irrigated area by the secondary effluent of the WWTP are 909 ha for vineyards and 983 for citrus.

These participation rates for irrigation volumes require slight dilution calculated for viticulture, to preserve the objectives of quality of receiving waters; Moreover, an additional contribution for citrus could be made and adjusted by a spread of around 5.02 tonnes per hectare sewage sludge from the same STEP to achieve expected returns, as these sludge have no agricultural use including limits the amount introduced is low.

The calculated values are interesting for agricultural reuse of these effluents whose interest may be a response to critical situations whose impact is:

- in economic level, this valuation will allow quantitative resource preservation conventional water, while also allowing less use of mineral fertilizers marketed and treatment costs in STEP gain;
- at the ecological level, the beneficial effect of this valuation is the large purifying powers of the soil and plants resulting in a reduction of the contamination of the natural environment by these receptors treated effluent without excess nutrients.

The health aspects of this issue will be addressed in a future article. Furthermore it appears that the operations research tools should allow a rational approach to this issue. One could indeed pose the problem as follows: given various possible sources of irrigation (treated water (dry season), treated water (wettest season), sludge (wet or dry), or storm water to which we know the available volumes and compositions N, P, K how to allocate these sources to maximize irrigated areas (taking into account the needs according to the type of crop) and minimize external fertilizer purchases. We could also in a second time to see the effect of purification systems (activated sludge, bacterial bed, lagoon, planted filters ...) on the objectives. It seems that so far few studies have focused on a coupling between processing systems and optimal reuse of treated water for irrigation.

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