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Evaluation of the fertilizing Supply of the by-products of the WWTP of Medea (Algeria)

S. Karef[1,2]*, A. Kettab[1], M. Nakib[1], S. Benziada[1], N.M. Chabaca[3], S. Benmamar[1], W. Boumalek[1], H. Bouanani[1], Y. Djillali[1]

[1]Research Laboratory of Water Sciences (LRS-EAU), Ecole nationale polytechnique d'ALger
[2] The University of Djelfa, Algeria
[3] National Superior Agronomic Schools, Algiers, Algeria

*Corresponding author: karef_salah@yahoo.fr ; Tel.: +213 560 351 508

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ABSTRACT/RESUME

Abstract: *In Algeria, freshwater resources are scarce and vulnerable, and the availability of drinking water per capita is in worrying decrease. Existing water resources are threatened by pollution due to concentration of urban and industrial wastewater discharges into receiving waters. Reuse of sludge and treated water is a solution to cope with the increasing demand of water resources for irrigation. At the same time, this is one way to reduce impacts on the environment and provide the nutrients that fertilize the soil. This allows an economy of water resources upstream and reduced downstream pollution.*

The present work aims to characterize sludge and the treated waters of the WWTP of Medea and assess their potential and fitness for agricultural use. The physico-chemical and bacteriological results revealed that for sludge, the C/N found indicates important nitrogen availability. This report is related to the low amount of organic matter it contains. For treated water of the WWTP to the current state are highly charged with fecal coliforms and can not be reused without chlorination and their high salinity limits their reuse for certain crops.

I. Introduction

In Algeria, freshwater resources are scarce and vulnerable, and the availability of drinking water per capita is worrying decrease [1]. She is ranked among the most disadvantaged countries in terms of the water potential. Indeed, at present the theoretical scarcity threshold set by the World Bank at 1000 m3/capita/year is far from being achieved with an average availability of 500 m3/capita/years [2].

In contrast, wastewater production increases and their reuse are as a first response to this situation of water shortage for irrigation. The wastewater Treatment generates the treated water and the sludge that are potentially reusable in agriculture according to their determinative composition and their fertilizer inputs.__The agricultural use of sludge can be considered as the best suited of recycling to rebalance biogeochemical cycles (C, N, P ..) for the protection of the environment and of a very great economic interest. It aims to safeguard natural resources and avoid any organic material wastage due to incineration or burial in landfills [3]. The sludge can thus replace or reduce the excessive use of expensive fertilizers.

It is in this context that this study focuses essentially on the potentiality of agricultural reuse of treated wastewater and sludge generated by the WWTP of Medea city.

II. Materials and methods

The samples of sludge and water were analyzed in the laboratory. The material and methods of analysis are given in Table 1.

III. Results and discussion

With the aim to assess the potentiality of agricultural reuse of these byproducts. A study period of 12 months was chosen during the year 2013. The results of analyzes carried out on different samples of sludge and treated water are presented and interpreted for the two fields as follows:

III.1. Sludge field

The parameters analyzed for this field are given with their results in Table 2.

III.1.1. Mohlman index MI

The MI measures the behavior of sludge in biological reactor (BR). Indeed, the MI values of between 50 to 150 ml / g, ensure good sludge settleability. Below 50 ml/g, the sludge risk to form deposits. Beyond 150 ml/g, we risk of having the phenomenon of bulking [4]. The mean value of IM found 52.12 ml/g reflects a good availability of mud settling.

III.1.2. Dryness of the sludge

We obtain a sludge at different percentages of dryness: liquid sludge (4-10%), pasty sludge (10 to 25), solids sludge (25-50%), granulated sludge or in powder for a dryness higher than 85% [5], which gives the solid character of the WWTP sludge of Medea, for a mean dryness found of 45%.

III.1.3. Organic matter

The sludge of the Medea WWTP contains 58% of organic matter in the dry matter, it is a coherent value with the report C/N found of 8. Once spread on the soil, the micro-organisms present in the soil degraded in part organic matter provided by the sludge and transforms them into mineral elements available to the plant. Another part of the organic matter is incorporated into the soil and contributes to the maintenance of a favorable structure for root development [6].

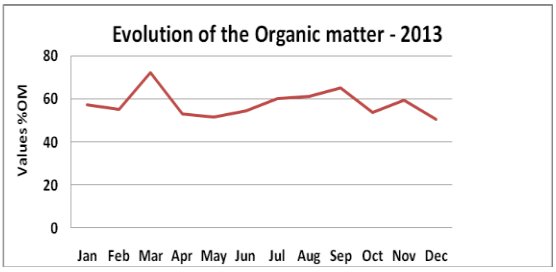

Figure 1. *Graphic representation of the evolution of the Organic matter in sludge of* WWTP Medea

III.1.4. Ratio C/N

It is recognized that organic fertilizers having C/N ratios below 20 are mineralized quickly and can release significant amounts of nitrogen to crops [7]. The C/N ratio of the sludge is 8 (Table 2) less than 10. Therefore, the mineralization of the organic matter contained in the sludge should begin short time after land application, thus making it available quickly large quantities of nitrogen at cultures. The nitrogen in sewage sludge is quickly released for use by the plant. Carbon is quickly assimilated by soil microorganisms and does not maintain the soil humus stock [8].

III.1.5. Potassium

Indeed, potassium excreted in the urine, being very soluble, tends to stay in solution in wastewater and be released into the treated effluent [7].

Sludge samples analyzed in the laboratory gave an average concentration of potassium (K_2O) of 0.22% of the dry matter, it is a low value. According to [8], this sludge can be advantageous for fodder cultivation in soils naturally rich in potassium.

III.1.6. Phosphorus

For a spreading of sludge, phosphorus migrates very slowly to the tablecloth or surface water because according to [9], phosphorus is strongly adsorbed to soil particles. The phosphorus (P2O5) assayed in our samples, representing 0.37% of the dry matter, it is an interesting contribution and can cover crop needs and there is no risk of leaching.

III.1.6. Metal trace elements

Analysis of samples of sewage sludge during 2013, have given the following results in table 3:

The low contents found of metals trace elements in sludge of WWTP Medea compared to regulatory limits do not cause any negative effects in their land application.

Table 1. *Results of analysis of MTE in the sludge of the WWTP Medea*

MTE	Concentration (mg/kg of DM)*	Regulatory limit values
Fe	1200	/
Mn	82.36	/
Cd	0.52	10
Cr	11.52	1000
Cu	43.38	1000
Ni	14.09	200
Zn	260	3000
Cr+Cu+Ni+Zn	329	4000

III.2. Water field

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III.2.1. Pathogens

Table 2. *Materials and methods of analysis*

Parameter	Material	Analysis methods
SLUDGE		
VSS	Oven at 550 ° C mark Nabertherm 30-3000°C	2h calcination at 550°C
Dryness	Oven at 105 °CBinder -Balance KERN Als 220	24h drying at 105 ° C
Sludge Index SI	transparent test tube	30 min settling
TKN	Digester- distiller / Buchi	KJELDAHL
Ca^{++},Mg^{++},Na^{+},K^{+}, MTE	AAS brand Perkin Elmer type AAnalyst 200	AAS
Assimilable phosphorus	Colorimeter brand JENWAY model 6051	JORET- HEBERT
Organic carbon	Titration with a solution of Mohr's salt	WALKLEY
WATER		
Pathogens	Ramp filtration - Oven Model Binder	Colimetry - Streptometry
pH	pH-meter type Hach SensIon 1	Potentiometry
Electrical conductivity	Conductimeter type Hach SensIon 5	Conductimetry
BOD_5	Flasks OxiTop IS12, WTW- Enclosure 20 °C	Respirometric
COD	Heating block Brand Behr- Labor Technik	Oxidation by $K_2Cr_2O_7$
TSS	Centrifuge Hermle Z300 - oven at 105°C	Filtration – Centrifugation
Ca^{++}, Mg^{++}, K^{+}, Na^{+}, MTE	AAS Perkin Elmer AAnalyst 200	AAS
PO43-,NH4+, NO3-	Spectrophotometer HACH DR/4000 V	Spectrometric

Table 3. *Results of analysis of the sludge parameters of the WWTP Medea*

	MI ml/g	Dryness %	OM %	C_{org} %	N_{TK} %	P_2O_5 %	K_2O %
Mean value	52.12	45	58	32.86	4.1	0.37	0.22

Bacteriological analyzes that relate to the quantification of pathogens have given the following results:

Table 4. *Results of bacteriological analysis of treated water of Medea*

Parameters	Results CFU/100mlx1 0^4	WHO standards (CFU /100ml)
Total colifor	25.12	/
Fecal colifor	18.85	≤ 1000
Fecal streptoc	10.32	/

The average load of fecal coliforms of treated water is 18.85x104 CFU / 100ml and 10.32x104 CFU / 100ml for fecal streptococci. We note that the concentrations of Fecal Coliforms are quite high in well above standard retained by WHO for irrigation water which is ≤1000 cfu / 100 ml [10]. Which takes us to consider that these treated water is unacceptable for irrigation

III.2.2. pH

The mean measured pH of the wastewater from inlet to outlet of the WWTP of Medea, ranges from 7.6 to 7.3, it is a neutral pH; conform to water intended for irrigation that has a pH between 6.5 and 8.4 [11].

III.2.3. Electrical conductivity (EC)

The electrical conductivity is probably one of the simplest and most important for the quality control of waste water. It translates the degree of overall mineralization; it provides information on the salinity. The average values of the recorded electric conductivity vary from 2390 µS/cm at the inlet and 2295 µS/cm at the outlet. These values confer on the water according to [11], a slight to moderate irrigation restrictions. The effluents of the WWTP of Medea are very high salinity and belong to classes IV which agricultural use is possible on particularly resistant crops [12].

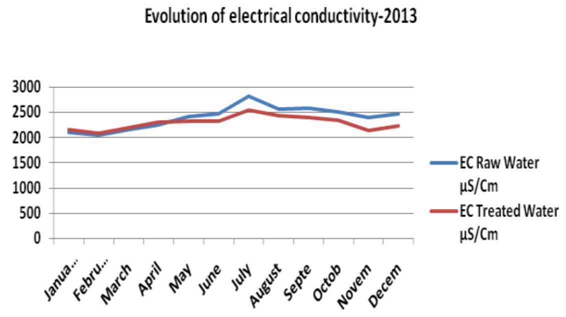

Figure 2. *Graphic representation of the evolution of the EC at the inlet and at the outlet of the WWTP.*

III.2.4. Total Suspended Solids (TSS)

The raw water registers a TSS of 810 mg / l, against a concentration of 25.4 mg / l in the treated water; it means a treatment yield of 97%. The treatment of particulate pollution is very effective at the WWTP especially if we consider that the standards of TSS for the rejection of treated water is <30 mg / l according to the USEPA recommendations [13].

III.2.5. Biological oxygen demand (BOD_5)

According to [14], the organic matter has an adsorption capacity of the chemical elements (cations and anions) ten times as clay; and no doubt, organic matter Helps improve soil structural stability by relaunching the soil microbial activity and increasing water retention.

For BOD_5, the average recorded concentration varies from 450 mg/l at the inlet to 20 mg/l at the outlet of the WWTP, giving a treatment yield of 95.5%. The concentration of BOD_5 to the outlet-is less than 30 mg / l, a limit value required by the recommendation of the USEPA [13].

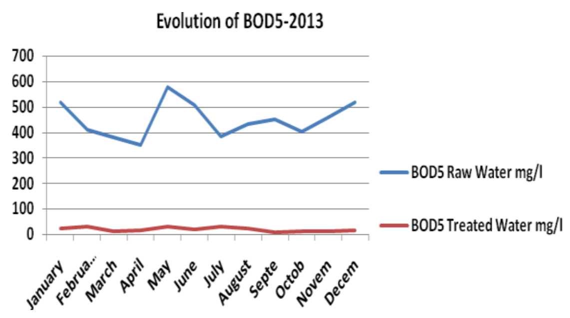

Figure 3. *Graphic representation of the evolution of BOD5 to the inlet and the outlet of the WWTP.*

III.2.6. Chemical oxygen demand (COD)

The COD registered at the inlet to the WWTP is 699 mg/l, against a value of 95mg/l recorded at the outlet, this gap shows the abatements pushed in the treatment process ie 86.4% of yield,

III.2.7. SAR (sodium adsorption ratio)

The SAR which expresses the relative activity of sodium ions in exchange reactions in soils, it influence the salinization of the soil and the infiltration rate which is a function of salinity (electrical conductivity and SAR [15].

The ionic species of SAR, when analyzed, have given the following results [Na +] = 90 mg / l, [Ca ++] = 101 mg / l and [Mg ++] = 35 mg / l which gives an SAR of 1.96.

According to the FAO guidelines cited by [16] for water with SAR between 0 to 3 and conductivity higher at 700 µS / Cm, the degree of restriction on the use in irrigation is zero. We must therefore take into account two factors, salinity and SAR, to assess the impact of the irrigation water quality on the infiltration speed.

III.2.8. Fertilizers

The nutrients being in large quantities in the waste water, which are important in agriculture, are nitrogen, phosphorus, and sometimes potassium.

III.2.8.1. Nitrogen

After treatment, the nitrogen in the treated water is found in oxidized form ammonia (NH_4^+) and nitrate (NO_3^-). Laboratory analyzes have shown an inverse proportionality between the two forms with a concentration of NH_4^+ ranging from 25 mg / l to 3 mg / l from the inlet to the outlet, unlike NO_3^- nitrates which are 4 mg / l at inlet and 19 mg / l at the outlet, this is due to the nitrification which oxidizes NH_4^+ in NO_3^-. The treated water of the WWTP Medéa, according to FAO guidelines [16] ,that specifies nitrates NO_3^- water concentrations ranging from 5 to 30 mg/l , are in the restriction interval of lightweight agricultural use to moderate .

In some cases, the nutrients in wastewater can be in quantities greater than that required for the balanced growth of crops and can potentially stimulate excessive growth of vegetative parts of crops rather than flowers and seeds [17].

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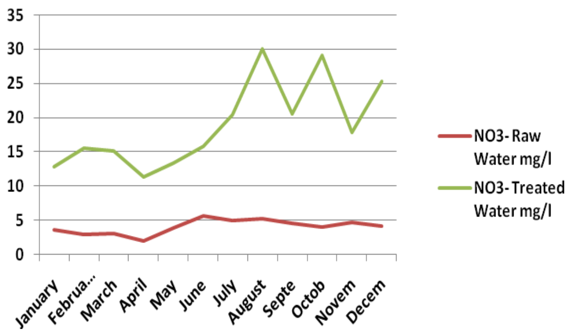

Figure 4. *Graphic representation of the evolution of NO_3^- at the inlet and the outlet of the WWTP-2013*

III.2.8.2. Phosphorus

Wastewater is an important domestic source of phosphorus, which is essential for plant development, especially for root growth and maturation of fruits and seeds.

The water analysis results show that the phosphates vary from 3.6 mg/l from WWTP inlet to 2 mg/l at its outlet; it is a usual value in the irrigation water.

III.2.8.3. Potassium

The results of the analysis of treated water gave an average potassium concentration of 18 mg/l; is considered a normal value and without any negative effect because according to [18] the potassium content in wastewater does not cause harmful effects on plants or the environment. It is an essential macronutrient that favorably affects soil fertility, crop yield and their quality.

III.2.9. Metal trace elements

According to [19], when processing wastewater in treatment plants, most of the metal is retained in sewage sludge. Iron and Manganese are heavy metals interesting and do not pose a health problem [20].

Analysis of treated water samples has given the contents of Fe and Mn respectively 1.3 mg/l and 0.19 mg/l. These very trace contents are below that the thresholds set by FAO [18] and will have no toxic effect on either the ground or on the plant.

And for copper and zinc according [20] are interesting metals for plants and posing a health problem. Based on the analyzes, their contents in the treated water are respectively, 0.07 mg/l, and 0.15 mg/l. These are negligible values compared to the threshold set by the FAO.

IV. Conclusion

The Algeria confronts a situation of severe water shortage that hinders any development of the country and threatens the future of coming generations. To remedy this, She is called seriously examine and mobilize other unconventional resources.

The main objective of our work was for an eventual exploitation of unconventional resources, to examine the potentiality of agricultural reuse of sludge and treated water from the Medea WWTP by characterization of its byproducts during the year 2013, which gave for the two fields:

Sludge field:

The monitoring of parameters analyzed sludge shows that the organic matter is 58% of the dry matter; this value is consistent with the C/N ratio found to 8. Thus, the mineralization of the organic matter contained in sludge should begin short time after land application, thus making it quickly available large quantities of nitrogen to crops. The nitrogen in sewage sludge is quickly released for use by the plant. The Carbon is rapidly assimilated by microorganisms of the soil and does not maintain the soil humus stock.

For the Potassium (K_2O), a quantity of 0.22% in the sludge is a low value. This sludge can be advantageous for fodder cultivation in naturally rich soils in potassium. An amount of phosphorus (P_2O_5) of 0.37% can cover crop needs and causes no risk of leaching.

The low contents of metal trace elements in sewage sludge of Medea do not cause any negative effects on their land application.

Water field:

In the absence of chlorination at the outlet of the WWTP, the concentrations of Fecal Coliforms are quite high and lead us to consider that the treated water is unacceptable for irrigation and is potentially reusable, once that chlorination is put into operation. A mean conductivity of 2295 µS/cm at the outlet of the WWTP gives to the water a restriction slight to moderate in irrigation. The WWTP effluents of Medea have a very high salinity whose agricultural use is possible on particularly resistant crops. The nitrates of treated water have a concentration of 19 mg/l which confers them a restriction for agricultural use, mild to moderate. The phosphates at the outlet of the WWTP have a concentration of 2 mg/l, which is a usual value in the irrigation water. A potassium concentration of 18 mg / l in the treated water does not cause harmful effects on plants or the environment. It favorably affects soil fertility, crop yield and their quality.

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