

## Evaluation of trace metals in sewage sludge from a wastewater treatment plant with perspective of valorisation

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### ABSTRACT/RESUME

*The increasing quantities of sewage sludge from wastewater treatment plants are a great source of worry especially concerning their impact on the environment. Managing such sludge is the basis for a successful general sanitation scheme.*

*The present work subject matter is the evaluation of pollutants present in the sewage sludge recovered from urban wastewater treatment plant of the town of Boumerdès, Algeria, which is treated wastewater from three (03) towns: Boumerdes – Corso – Tidjelabine. For this study, we followed the evolution of some physical and chemical parameters such as the concentration of trace metals which we have analysed mineralogically through the use of X-ray fluorescence and then compared to the French standard NF U 44-041. The NF U 44-041 standard concerns the reuse of sewage sludge as fertilizer in land application. Several sewage sludge samples have been analysed in the present work.*

*The analysis of the sewage sludge physical properties has revealed a low percentage of dry matter (total solids) and a high percentage of organic matter. The chemical characterization of the sludge helped to evaluate their pH and polluting power. Overall the pH level of the sludge was approaching neutrality and their concentration in trace metals was below the thresholds defined by the NF U 44-041 standard. Thus, municipal sewage sludge does not represent any danger to the environment that thus can safely be used in agriculture.*

### I. Introduction

The Algerian National Office of Sanitation (i.e. l'Office National d'Assainissement ONA) is a national public company with industrial and commercial character created in april 2001 under the Ministry of Water Resources of Algeria. The missions of this company are: management, operation and maintenance of wastewater treatment infrastructures [1].

The treatment of wastewater in the wastewater treatment plants (WWTP) generally leads to the formation of large quantity of sludge. Due to constant growth of the sewage sludge (SS), it

deserves a special consideration. Sludge management, valorization and elimination, were problematic as well as the other waste [2]. The agricultural use is the most attractive solution to recycling sludge as fertilizer. Knowledge of heavy metal content in the sludge are the most important factors in selecting the disposal alternatives [3]. Therefore, it is important to evaluate the rates of various pollutants in sewage sludge against the limits defined by the adopted standards. With the objective of identifying valorisation perspective for the sludge as fertilizer, the present paper presents an analysis completed on the low charge residual activated SS from the WWTP of Boumerdès which

is supported by ONA. The WWTP of Boumerdès treats wastewater from three (03) towns: Boumerdès – Corso – Tidjelabine, Algeria.

We took special care in determining the sludge's amounts (concentrations) of trace metals (TM) which, by definition, are metal or metalloid elements whose concentration does not exceed 1000 mg/kg in a given sample or for a given environment [4] and comparing them with the NF U 44-041 French standard.

## II. Matériel et méthodes

The dewatered SS studied is a biological sludge. It is collected from the output of the band press of the WWTP of Boumerdès which has a maximum treatment capacity of 15000 m<sup>3</sup>/day. Six samples were used for the analysis. They were collected over a period of three months between May 2012 and July 2012. These samples are designated from here on by the indices SS1 to SS6. They were conserved at 4°C until their use in the laboratory. Sludge characteristics were measured in triplicates.

- The dried matter or total solids (TS) is determined by drying the samples in an oven at 105°C until a constant mass to remove moisture according to the standard NF EN 12880. The volatile solids (VS), meanwhile, are measured by the loss on dried sample ignition at 550°C for 2 hours according to the standard NF EN 12879. The volatile solids content obtained are equivalent to the organic matter.

- The pH value expresses the actual acidity and takes into account the free hydronium ions (H<sub>3</sub>O<sup>+</sup>) in the liquid phase [5]. Its measurement in the SS is carried out according to the standard EN 12176 using a pH-meter model WTW pH 330.

- The standard used to determine the electrical conductivity (EC) is the NF ISO 11265 norm using an EC-meter model HANNA EC 214.

- The chemical composition test aims to measure the overall concentration of pollutants and other constituents present in the sludge. It helps to determine the quantities of the heavy metals and the major elements composing the SS samples. The quantitative analysis is performed on sludge's samples using X-ray fluorescence analyser NITON XL3t. It allows finding the concentration of trace metals (TM) and Axios Panalytical minerals for the major elements.

## III. Results and discussion

### III.1. Physical Properties: Total solids (TS) and volatile solids (VS)

Testing the physical properties of the sewage sludge shown in Figure 1 reveal that the total solids content not exceeding 16% by weight (between

14.19 % and 15.99 %) so the moisture in dewatered SS is relatively high (between 84.01 % and 85.81 %). Examining the physical properties of the sludge has also revealed that it contains a high percentage of volatile solids. As illustrated in Figure 2, the VS to sewage sludge weight rate easily exceeds half the sludge's weight. In the samples tested, it was between 52.25% and 63.40% and shows only small differences between individual samples, which proves that it has good fertilizer properties [6]. This high weight percentage is due to the fact that the SS samples used have an urban origin. According to Durand (2002), the quantity of the organic matter present in the sludge is a good indication of how much pollutants it retains. The heavy metals are best preserved in the SS when it has a high level of organic matter [7]. As shown in Figure 1, the slightly variation of TS's weight rate from SS1 to SS6. The same case is shown in Figure 2 concerning VS's weight rate. This observation indicates a good reproducibility of the results.

Figure 1: TS's percentage by weight variation from SS1 to SS6

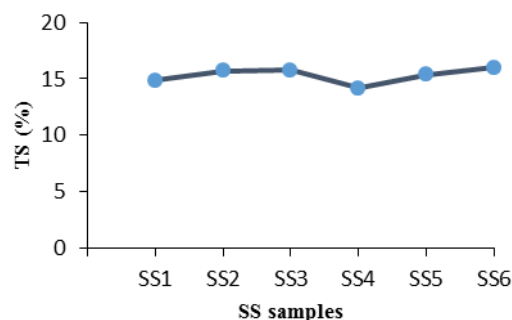
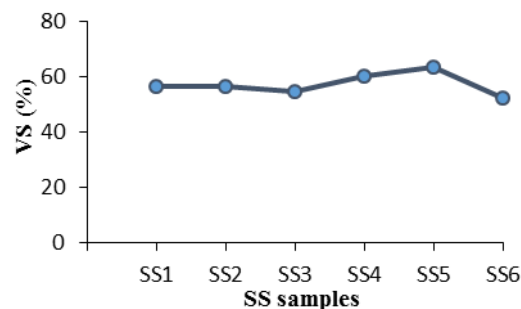


Figure 2: VS's percentage by weight variation from SS1 to SS6.



### III.2. Chemical properties

#### III.2.1. pH and electrical conductivity (EC)

With regards to pH (Figure 3), the reaction of the tested sewage sludge was from slightly acidic to neutral (pH 6.80-7.01) and typical of sludge

produced during the biological treatment of municipal sewage [6].

The electrical conductivity is a measure which gives an approximation of the concentration of soluble salts present in the sample [8]. It is expressed in micro Siemens per centimetre ( $\mu\text{S}/\text{cm}$ ). The test completed in this section shows that the EC of the tested samples is relatively small, and is has slightly variation between 454 and 552  $\mu\text{S}/\text{cm}$  (Figure 4). The conclusion that should be made here is that the tested sludge has a low concentration of soluble salts.

Figure 3: Experimental pH data from SS1 to SS6

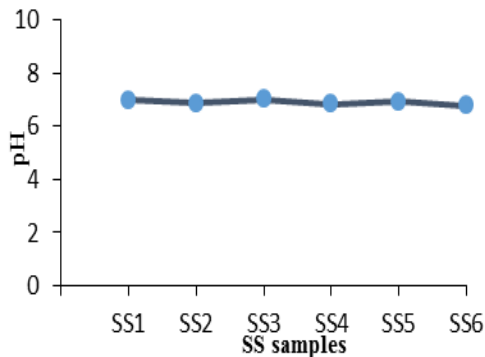
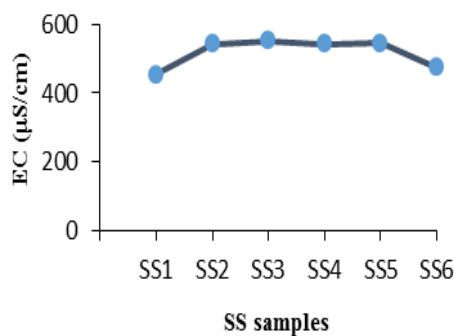


Figure 4: Experimental EC data from SS1 to SS6



Due the small variation values of TS, VS, pH and EC parameters from SS1 to SS6 samples, we have summarized them in Table 1 bellow as the average of the six (06) SS samples studied.

Table 1: Average of TS, VS, pH and EC of the six (06) SS samples studied

Parameters	Average values
TS (%)	15.31
VS (%)	57.17
pH	6.91
EC ( $\mu\text{S}/\text{cm}$ )	518

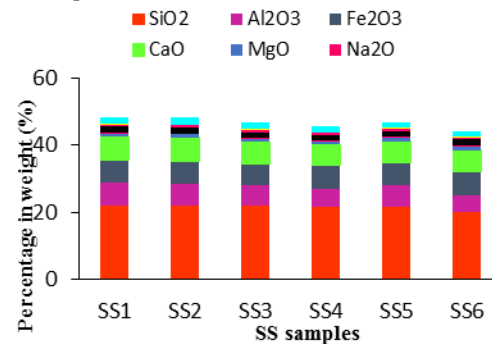
TS (%)	15.31
VS (%)	57.17
pH	6.91
EC ( $\mu\text{S}/\text{cm}$ )	518

### III.2.2. Major Elements

The chemical composition of the sludge is expressed in percentage in weight of the corresponding oxides of different elements and the results are shown in Figure 5 below.

These results also demonstrate the reproducibility in the sludge production [9]. Figure 5 shows that the predominant elements contained in the SS, expressed as oxides, are mainly silica, alumina, iron oxide and calcium oxide.

Figure 5: Percentage of major elements' weight in SS samples



### III.2.3. Trace metals (TM)

The concentrations of Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn and the sum of Cr+Cu+Ni+Zn in the six (06) SS (the dry sludge) samples in front of their limit values according to the French standard NF U 44-041 are given in Table 2.

Tables 2 shows that Zn typically presents the highest concentrations in sludge in the range of 72.813-88.660 mg/kg. Pb is found at low concentration only in two samples (88.660 mg/kg in SS2 and 8.274 mg/kg in SS4) of sludge but in the other samples it is less than the limit of detection of the apparatus whereas Cd, Cr, Cu, Hg, Ni and Se are typically present at concentrations below the limit of detection. The concentrations of the sum of Cr+Cu+Ni+Zn are in the range of 72.813-99.474 mg/kg. All these concentrations do not exceed the double amount of corresponding reference as it shows in the norm (Table 2). This result is in line with the origin of wastewater treated in the WWTP which are urban.

According to the standard NF U 44-041 sewage sludge of Boumerdès can be used in agriculture

because the trace metals concentrations are under the limit

Table 2: Variation of TM in the sludge samples from SS1 to SS6.

Metals (mg/kg of dry sludge)	NF U 44-041 limit value (mg/kg of dry sludge)	Sewage Sludge					
		SS1	SS2	SS3	SS4	SS5	SS6
Cd	20	< ld	< ld	< ld	< ld	< ld	< ld
Cr	1000	< ld	< ld	< ld	< ld	< ld	< ld
Cu	1000	< ld	< ld	< ld	< ld	15.907	< ld
Hg	10	< ld	< ld	< ld	< ld	< ld	< ld
Ni	200	< ld	< ld	< ld	< ld	< ld	< ld
Pb	800	< ld	7.620	< ld	8.274	< ld	< ld
Se	100	< ld	< ld	< ld	< ld	< ld	< ld
Zn	3000	< ld	88.660	76.700	75.238	83.567	72.813
Cr+Cu+Ni+Zn	4000	88.235	88.660	76.700	75.238	99.474	72.813

ld: limit of detection of the apparatus.

#### IV. Conclusions

The physical and chemical characterisation of the sludge allows to determine their composition and own characteristics. The data obtained from the characterisation also helps gain a better understanding and translation of experimental results.

The results from the tests completed on this paper show that the sewage sludge low load obtained from the wastewater treatment plant of Boumerdès (i.e. SS1 to SS6) are very reproducible. The tested sewage sludge was characterized by good physical properties (high moisture content from 84.01 % to 85.81 % and high organic matter content from 52.25% to 63.40%) and suitable pH from 6.80 - 7.01.

Concerning chemical properties, the sewage sludge from the wastewater treatment plant of Boumerdès were characterized by very low concentrations of heavy metals. Their values are well below the French NF U44 -041 standard and thus have a limiting the risk of contamination to the environment.

As explained in the beginning of this paper, the main aim of this study is the characterization of sludge from the valorisation perspective. As shown by the initial results of this work and considering the good physical and chemical properties of the sewage sludge produced at the municipal Treatment Plant in Boumerdès, this goal seems to be achievable in the field of agriculture. However, an extended experiment over a longer period of time would help consolidate this conclusion.

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