SLUDGE OF WWTPs, FROM WASTE FAMILY TO SUSTAINABLE DEVELOPMENT

D. Djafari [1 *], B. Mekerta[1], R. Zentar [2], A. Semcha [1]
[1] Université Ahmed Draia - Adrar, Algérie
[2]Laboratoire de Génie civil et géo-Environnement, Lille de Nord de France, Ecole des Mines de Douai, France
[*]djafari-d@univ-adrar.dz

Abstract- *Excess sludge treatment and disposal currently represents a rising challenge for wastewater treatment plants due to economic, environmental and regulation factors. There is therefore considerable impetus to explore and develop strategies and technologies for reducing excess sludge production in biological wastewater treatment processes. The main goal of the treatments applied to rough sewage sludge is the reduction of both volumes and injuries. In this paper we presented the possibility of incorporate sludge ash into the composition of cement. An evolution of the mechanical compressive strength according to time (for 2, 7 and 28 days), standard mortars realized with eco-cements developed showed the viability of the valuation recommended for these ash.*

Keywords*: Sludge; Treatment; Waste; Sustainable development*

INTRODUCTION

During the second part of the twentieth century, the question of water pollution has taken worrying proportions whereas, at the same time, water consumption increased together with the demographic explosion. In industrialised countries the reduction and the control of water consumption is linked to the optimisation of processes for industrial and domestic wastewater treatment [1]. Excess sludge treatment and disposal currently represents a rising challenge for wastewater treatment plants **(Fig.1)** due to economic, environmental and regulation factors. There is therefore considerable impetus to explore and develop strategies and technologies for reducing excess sludge production in biological wastewater treatment processes [2].
Primary and secondary sludge produced in wastewater treatment plants is composed of a complex mixture of organic and mineral, dead and alive matter that is further treated using specific processes of treatment of this excess sewage sludge. Such processes aim at providing a material usable in the classical fields of conversion of biological wastes such as agricultural reuse [3], dumping, incineration or thermo-chemical conversion [4]. The main goal of the treatments applied to rough sewage sludge is the reduction of both volumes and injuries. At the exit of wastewater treatment processes, sewage sludge is composed of 99% of water and occupies considerable volumes. Sewage sludge is also a highly fermentescible matter releasing strong odours. As a consequence, in order to reduce sludge volumes and injuries, they have to be submitted to various treatments (concentration, aerobic stabilisation or anaerobic digestion, conditioning, dewatering, storage, etc.). In Algeria, the National Office of Cleansing (ONA) manages 70 WWTPs. Total quantity estimated of sludge produced summers 179 780, 42 m^3 [5]. Capacity for treatment, the number of WWTPs as well as the quantity of sludge produced for each area are presented in **(Fig.2).**

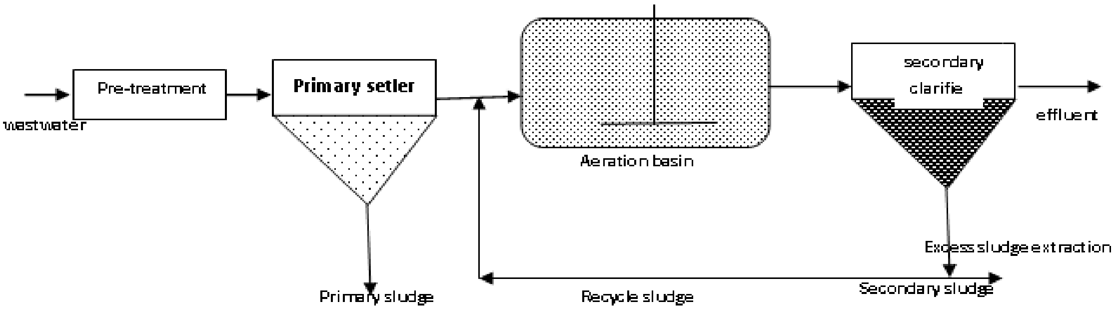
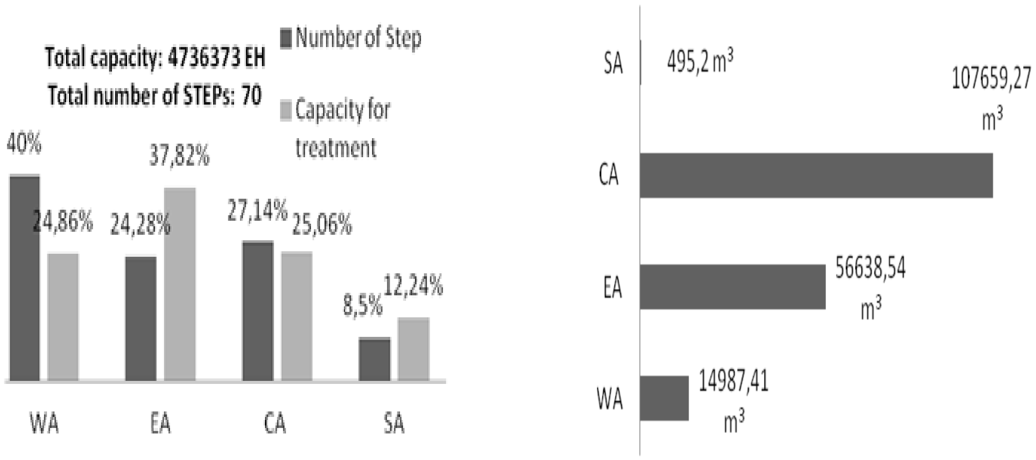


Fig.1. Scheme of an activated sludge wastewater plant



(a) *(b)*

Fig. 2. (a) The number of WWTPs and capacity for treatment per area, (b). Quantities of sludge produce per area. (ONA, Algeria). CA: central area, WA: western area, EA: eastern area, SA: southern area.

Several sectors exist for the elimination of this sludge, but the choice remains often related to the cost of the installation, at the origin of sludge, the added-value of the product which results from this and the impact of the sector retained on the environment. The garbage dump (also called storage) is a little developing and legally prohibited procedure in many countries [6]. The sludge incineration is prohibitively expensive and present a risk related to the impact of toxic gas on the atmosphere such as that of dioxin [7]. Energy valorization in the case of the production of biogas as a source of heat and electricity on the one hand, and agricultural valorization in the production of fertilizer and compost on the other hand, constitute clean technologies which minimize the risks of pollution ADEME, 2001 [8].

In this paper, after calcite of sludge of WWTPs, various composition of the green-cement (with increasing amount of substitution in the raw cement) was tested. To evaluate the performance of the new binders, prismatic samples made of mortars were carried out and tested in compression.

MATERIAL AND METHOD AND CHEMICAL ANALYSIS

Origin of sludge sample

The samples of the studied sludge were taken at the level as of beds of solar drying of the WWTPs known "Rochet" in the wilaya of Sidi Bel Abbes (west of Algeria, 400 km from Algiers (Algeria)). The taken samples were preserved at a temperature of - 4 ° C in order to eliminate any risk of fermentation.

Preparation of the eco-cement

For the preparation of the eco-cement; mixtures of clinker, of ash resulting from the incineration of sludge WWTPs and Gypsum are carried out. Before carrying out a chemical and mineralogical analysis of the various components and the mixtures of the finished products realized, a neat crushing was made in a micro-crusher. The duration of crushing with respect to Blaine surface was fixed to three minutes. The compositions of formulated eco-cements are given in Table 1.

Table1. Composition in mass proportion of the developed cements

Cements	Gypsum (%)	Clinker (%)	Ash (%)
EC_0	5	95	0
EC_5	5	90	5
EC_{10}	5	85	10
EC_{15}	5	80	15

Chemical and mineralogical of eco-cement

For the characterization of ashes resulting from the calcinations of sludge from WWTPs, analyses of X-ray diffractometry were undertaken. In these experiments, the diffractometer used is of the type OXFORD 1000 MDX (Multi-dispersive X-ray fluorescence analyzer element). (Table 2)

To evaluate the performance of the developed eco-cement **(Fig.3),** prismatic samples (40mmx40mmx160mm) of a mortar made of eco-cements were tested for compression. The mortar used is composed in mass, of one part of cement (or eco-cement), three parts of standard sand and a half part water (W / C = 0.5).

Each batch for three test specimens comprises 450 g ± 2 g of cement, 1350 g ± 5 g of standard sand and 225 g ± 1 g of water.

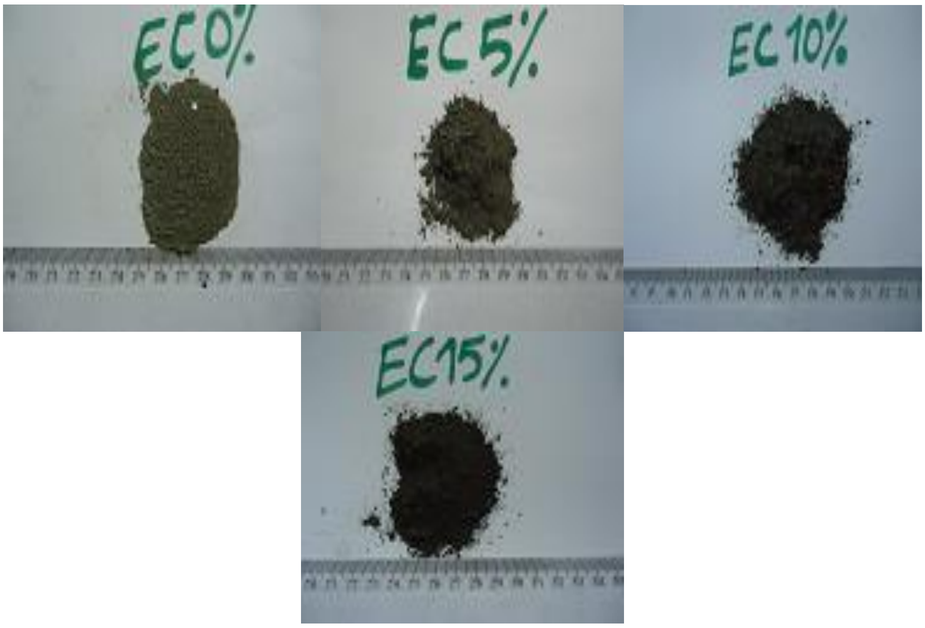


Fig.3. Different cements developed [EC0% (TC), EC5%, EC10% and EC15%]

RESULTS AND DISCUSSION

Chemical and mineralogical analysis

The analysis realized on the mixes (Table 2) confirms that the addition of ashes resulting from the calcinations of sludge in the raw meal for the manufacturing of cement would certainly have required an additional source of lime.

Table2. Chemical composition of EC0, EC_5, EC_{10} and EC_{15}

Components (%)	SiO_2	AL_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	PAF
EC_0	22.66	5.07	3.77	61.54	1.74	0.164	0.938	2.58	1.61
EC_5	23.34	5.41	3.79	59.86	1.83	0.167	0.969	2.58	2.94
EC_{10}	23.78	5.69	3.82	58.13	1.89	0.173	0.988	2.57	4.37
EC_{15}	24.82	6.09	3.90	57.23	1.99	0.186	1.027	2.62	5.31

Mechanical tests

The mechanical tests of characterization consisted tests of tensile strength and tests in compressive strength were performed according to standard EN 196-1 on specimens made of a mortar which integrates various eco-cements.

The mechanical results presented in Figure 4 show that eco-cements used make it possible to develop strengths at the young age (7days) and beyond higher than the resistance measured on control samples (MT). This increase in strength can be attributed, with regard to the measured parameters, the specific surface area "Blaine" surfaces developed by eco-cements.

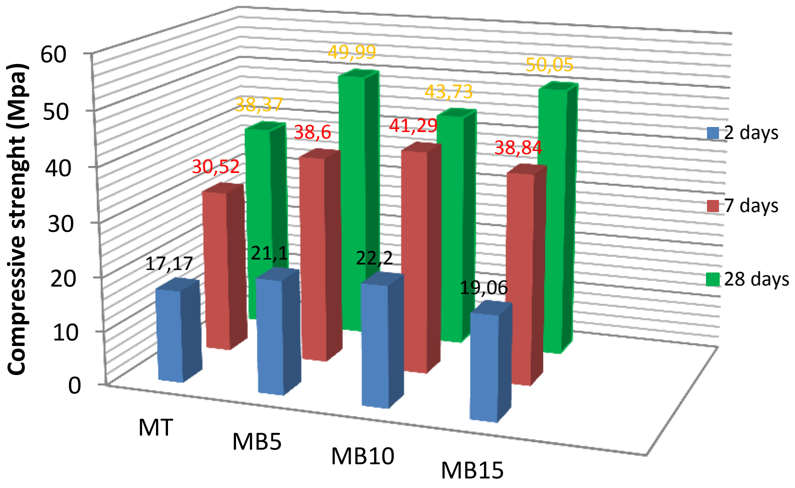


Fig. 4. Evolution of the compressive strength

CONCLUSION

The results of mechanical tests on specimens containing a control cement and eco-cement make it possible to conclude that they can be doubly valorized: the organic fraction is used in combustion (in the cement kiln) and them ash generated are incorporated in the chemical composition of the finished product (eco-cement). This will qualify our substitute cement as "eco-cement", as one hand it saves the same amount of cement and on the other hand offer a sector of exploitation of this waste. It is to note that after 28 days of curing, the resistances of samples made with green-cements exceed 50 MPa. The same trend is observed with specimens tested in flexion.

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