

## Evaluation of the Impact of Ni, Cr and Pb Contained in Effluents of an Industrial unit by the Process of Stabilization/solidification using Hydraulic Binders

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**ABSTRACT:**Stabilization/ solidification (S/S) of hazardous waste by hydraulic binders is one of the most promising ways to reduce the polluting nature of ultimate waste. This study conducted at the laboratory scale, to study of the influence of various parameters namely: the ratio L/S, the contact time solid/liquid, surface and medium of exposure...etc., on the environmental impact of ultimate waste synthesized and real-discharges of an industrial unit, stabilized/ solidified by hydraulic binders. The ANC test, pore water and leaching test on monoliths were carried on samples of the same material to study the influence of pH, L/S ratio and other parameters on the chemical speciation of the species (Pb<sup>2+</sup>, Cr<sup>+3</sup> and Ni<sup>+2</sup>) in granular materials. Monitoring of the changes in concentrations (TLM test), flows leached and cumulative concentrations of chemical species are used as a criterion for comparison. The use of X-ray diffraction (XRD) is effective for the determination of crystalline phases. The results of XRD may indicate the mechanisms and reactions of immobilization occurring in the process of S/S. The experimental results obtained for the scenario shown indicate that the release of chromium is purely diffusive in against the leaching of lead and nickel is combined by diffusion and chemical reaction.

**Key words:** Leaching, Characterization, Solubility, Ultimate waste (Pb<sup>2+</sup>, Cr<sup>+3</sup>and Ni<sup>+2</sup>), Portland cement

### INTRODUCTION

The environmental assessment methodology should be used to predict the danger of the ultimate waste on the environment and health of living beings, such as stabilization/ solidification of incineration waste of household waste by hydraulic binders. As water is considered the main vector of environmental pollution, responsible in the transportation, transfer and dispersion of soluble pollutants of ultimate solid waste; the characterization of the mechanism of leaching is considered an important step in predicting their long-term leaching. Commonly, the tools for estimation of leaching tests conducted in the laboratory are compliant with the regulations (NNI, 1994. NEN 7345-The Netherlands). The considerable progress in estimating the impact of waste on the environment was carried by the European Committee for Standardization who has defined an environmental assessment methodology by intrinsic characterization and dynamics of granular materials (ECS European Committee for Standardization CEN/TC 292/WG 6, 1997- European standard ENV 12

920) ( ADEME, 2002; Afnor, 2006 ; CEN/TC 292, 2006). In fact, a large number of experiments was carried out in recent decades on the characterization of ultimate waste, leaching and modeling long-term ultimate waste (Imyim *et al.*, 2000; Imyim *et al.*, 200). In this field, our research aims estimation and modeling of leaching of inorganic species in porous materials, stabilized / solidified by hydraulic binders. A set of procedures for environmental assessment of the impact of ultimate waste was proposed ( Imyim *et al.*, 2000; Imyim *et al.*, 200) is applied to a wide variety of conditions namely: composition of the materials (waste and pollutants) ( Imyim *et al.*, 2000; Imyim *et al.*, 2000; Imyim, 2000), particle size of materials (samples monolithic or granular), porosity ( Imyim *et al.*, 2000; Tiruta-Barna *et al.*, 2000) and leaching properties (demineralized water, alkali, sulfates) .These previous research has shown that the migration of inorganic species in porous materials in various conditions of leaching has two transfer mechanisms are: pure diffusion for highly soluble species (alkali metals) and diffusion /

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dissolution for sparingly soluble species. The chemical nature and properties of the internal transport of materials (porosity, diffusion coefficient) are considered as intrinsic parameters that determine the evolution of the pollutant in the porous matrix. Another set of parameters characterizing the conditions of the scenario are: fluid hydrodynamics (direct current or renewal sequence with contact time and different ratios L/S) (Imyim *et al.*, 2000; Tiruta-Barna *et al.*, 2000; Réthy, 2001; Cherly *et al.*, 2005; Xu *et al.*, 2008) and the type of reactor (column, reactor closed or open) (Tiruta-Barna *et al.*, 2001) may also contribute to the understanding of the release of pollutants in granular materials. Among the scenarios that describe the phenomena of leaching and their conditions, we cite mainly: immersion in water, infiltration of rainwater into a solid, a discharge of Household waste and water in contact with monolithic blocks (EA. NEN 7375, 2004). The objectives of our study related to this problem are not to propose a new test, but: determination of the influence of leaching conditions on the release of various chemical species contained in the porous matrix, performance evaluation of the scenario used. To accomplish these objectives, an experimental program was proposed. In the latter, Portland cement "Ain El-Kebira Algeria", materials containing pollutants (lead, chromium, nickel) were used in the formulations of cement matrices. Monitoring of long-term release of chemical species and polluting is provided by the TLM test. The intrinsic properties of the materials were characterized using two tests (balance tests liquid/solid). The samples of the same material were subjected to four dynamic tests in parallel in different leaching conditions; the main differences between the experimental tests are the conditions of contact S / L, particles size, liquid circulation.

## MATERIALS & METHODES

The determination of major and minor chemical elements in materials has necessitated the use of x-ray fluorescence on beads, ultraviolet spectrophotometry and atomic absorption (AAS-unit type AA-6501F) by setting solution samples according to NF X 31 151 (French Agency for Standardization 1995). The identification of mineral phases contained in the samples was obtained by X-ray diffraction (XRD). Testing of compressive strength were performed in the laboratory of Civil Engineering of University of Bejaia, using a press-type 65-L11M2 according to standard EN196-1, to examine the influence of the addition of pollutants (heavy metals) on the mechanical properties (initial and final setting times) of specimens aged 28 days. The Water Absorption Capacity (WAC or open porosity) of a waste stabilized / solidified is determined during the leaching test on monolith is the mass of

water absorbed by the dry waste taking into account the release of soluble species it also provides access to the porosity. It is calculated by the formula:

$$CAE = \left[ \frac{(m_f + \sum f_i + \sum p_i - m_{os})}{m_{os}} \right] * 100 \quad (1)$$

The open porosity of the material saturated denoted  $\varepsilon_i$  can then be determined by:

$$\varepsilon_i = CAE(\%) * d \quad (2)$$

(Imyim *et al.*, 2000).

Acid neutralizing capacity of the materials (NAC) is used to evaluate the power of acid-base materials and to understand the potential resistance of materials stabilized / solidified to assault acids (Imyim *et al.*, 2000). Solubilization with pH test (IPH) is brought into contact in parallel of various samples of each material with acidic or basic solutions of different concentrations for 7 days with L/S = 10 (Imyim *et al.*, 2000), eluates were then divided into two parts: one is acidified with nitric acid for chemical analysis, the other part will be used for the analysis of chloride ( $Cl^-$ ) and sulfate ( $SO_4^{2-}$ ). The test pore water (EP) and the maximum fraction mobilizable test (MMF), used to study the evolution in the composition of solutions to equilibrium with the decrease and increase, respectively, of the ratio L / S by extrapolating curves to the ratio L / S infinite. They also provide access to the concentrations of highly soluble elements initially contained in the pore water saturated. These tests were applied to the three synthesized materials (E(PbO), E( $Cr_2O_3$ ) and E( $Ni_2O_3$ )) and a real waste - waste of an industrial unit - E (s/s 5% of real waste) crushed (particle size less than 1 mm) and not dried, they consist of a set of contact in parallel samples with deionized water for different liquid / solid ratio. The leaching tests performed on the monolithic blocks are consistent with the procedure depth evaluation process of stabilization/solidification based on hydraulic binders proposed by ADEME (Imyim *et al.*, 2000). After a cure of 28 days in a humid room, the samples of size 8 \* 8 \* 21 cm<sup>3</sup> were cut with a saw to extract dry, of heart, samples of size 4 \* 4 \* 4 cm<sup>3</sup> to avoid carbonation phenomena (Omikrine *et al.*, 2009). The samples were dusted and weighed. The monolithic block, for each material, is placed in a glass test tube closed of volume of one (1) liter of deionized water or one liter (1L) of alkaline solution (composition: 1 g / l of Ca (OH) 2, 0.24 g / l NaOH and 0.45 g / l of KOH - pH = 12), suspended on a grid allowing the movement of solution of leaching. The Ratio fluid volume (cm<sup>3</sup>)/surface of the sample (cm<sup>2</sup>) is chosen in this study L/S = 10cm. The

experiment was performed at room temperature ( $20 \pm 3C^\circ$ ) and in the dark (Imyim *et al.*, 2000). The rate of change of the solutions is imposed by the contact time matrix /solution of 6h, 18h, 1d, 2d, 6d, 6d, 20d and 28 days for materials synthesized and 3h, 5h, 16h, 1d, 3d, 4d, 3d, 3d, 7d, 7d, 14d and 21 days for there al waste S/S, a total of 64 days of continuous leaching. We obtain so a solutions of leaching to characterize the physico-chemical parameters and their chemical composition. After each sequence of contact, the monolithic blocks are carefully drained and re-introduced into the leaching test with renewal of the volume of demineralized water. However, lixivants are filtered through filter paper to determine the mass of any particles retained on filter paper ( $P_i$ ) needed for the calculation of the CAE. The solutions obtained are then divided into two parts and analyzed following the procedure used in the IPH test. The TLM test results are chemical parameters of pH, conductivity and concentrations and flows of chemical species followed by release ( $Ni^{+2}$ ,  $Cr^{+3}$  and  $Pb^{+2}$ ), these results are presented graphically as a function of time of contact or average time calculated by the formula:

$$T_i = \left[ \frac{\sqrt{t_i} + \sqrt{t_{i+1}}}{2} \right]^2 \quad (3)$$

The amount leachable available is the amount of species that can be solubilized and could be released into the environment upon contact with the solution of leaching until its exhaustion is reached. For poorly soluble species, two experimental approaches have been developed for the determination of this quantity.

- The maximum amount extracted under extreme conditions of pH during the IPH test,

- The maximum fraction mobilized during the FMM test by extrapolating curves to L/S infinite.

These quantities expressed in mg / kg of dry material are converted because of their use in simulations as a concentration in mol / l of pore water, according to the quotient below (Imyim *et al.*, 2000):

$$S_0 = \frac{Q_{(max-ext)} * \rho}{Ma * P * 1000} \quad (4)$$

Where:

CAE : Water Absorption Capacity (%);

$m_{0S}$  : Dry mass start (kg);

$m_f$  : Mass of the sample saturated with water (kg);

$f_i$  : Mass of dry residue (kg);

$P_i$  : Dry mass of any particles retained by the filter paper (kg).

$S_0$  : Initial concentration of chemical species precipitate (mmol / l);

$Q_{(max-ext)}$  : Maximum amount of chemical species extracted (mg / kg );

$\rho$  : The density of chemical species (kg / m<sup>3</sup>) and P: porosity of the monolith in (%).

## RESULTS & DISCUSSION

The process of stabilization / solidification is studied in matrices of mortars based on Portland cement CEM-IIA 42.5 of the cement plant of Ain †El- KEBIRA Algeria, the chemical composition and physical properties of the employed cement are shown in Table 1. The other components used in their formulations are synthetic compounds waste of sand and inorganic pollutants PbO, Cr<sub>2</sub>O<sub>3</sub> and Ni<sub>2</sub>O<sub>3</sub> introduced as pure products of laboratory and real waste rich in nickel that its composition is given in Table 2. The mixing is carried out with double distilled water to avoid contamination by trace elements. The carbonation phenomenon is inevitable in any cementitious material exposed to air directly or indirectly. It results in the formation of calcite by consumption of hydrates, mainly portlandite and precipitation of calcite and water production. This result in the reduction of the porosity of the material. As the exposed faces are generally the molded faces, they are rich in cement pastes, thus carbonatable product (EA. NEN 7375, 2004). The precipitation of calcite results in a reduction of porosity, including area, reducing the material properties towards the leaching. Therefore, samples made †from mortar are protected as much as possible to the ambient air. We used a ratio W/C (water-to-cement ratio) of 0.5 to obtain a material with significant porosity percolating and promote the diffusion of chemical species (Cr<sup>+3</sup>, Pb<sup>+2</sup> and Ni<sup>+2</sup>) to the leaching solution.

The mass content of selected pollutant PbO, Cr<sub>2</sub>O<sub>3</sub>, and Ni<sub>2</sub>O<sub>3</sub> and real waste is 0.96%, 1.2%, 1.2% and 5% respectively compared to the total mass of the components for pollution levels considered plausible. The formulations of the materials synthesized and real are given in Table 3.

The test results of compressive strength ( $R_c$ ) and flexural ( $R_f$ ) are presented in Table 4. Each test was performed on triplicate. The obtained results for the synthesized materials show that the value of the compressive strength recorded for the material E (Cr<sub>2</sub>O<sub>3</sub>) is large compared to other values †recorded in the other materials. With regard to the material obtained by adding the real waste, its compressive strength is increased from 28 days to 6 months. The addition of

**Table 1. Chemical composition of CEM IIA 42.5**

	Composition chimique % massique							
	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	SO <sub>3</sub>
CEMIIA	23.76	5.05	5.15	62.15	2.18	0.38	0.13	1.2
Realwaste	23,64	7,75	3	34,10	nd	nd	nd	nd

**Table 2. Elementary chemical composition of the real waste**

Elements	Ni	Pb	Cr	Fe	Na	Ca	Zn	Cu	Mn
Concentration in % weight	8.00	0.16	0.07	1.61	6.21	4.75	0.15	0.30	0.07

**Table 3. mortar formulations**

The matrix (mortars)	Sand	Cement	Cr <sub>2</sub> O <sub>3</sub>	Ni <sub>2</sub> O <sub>3</sub>	PbO	Real	water	W/C
E (control)	63.33	24.98	0	0	0	0	12.49	0.5
E (Cr <sub>2</sub> O <sub>3</sub> , 1.2%)	61.33	24.98	1.20	0	0	0	12.49	0.5
E (Ni <sub>2</sub> O <sub>3</sub> , 1%)	61.33	24.98	0	1	0	0	12.49	0.5
E (PbO, 0.96%)	61.57	24.98	0	0	0.96	0	12.49	0.5
E (s/s-5% real waste)	53.37	24.95	0	0	0	5	12.47	0.5

**Table 4. Strength tests on mortars studied**

Designation	Waste adde	R <sub>c</sub>	Standard	R <sub>f</sub>	Standar
E (C, 0%) - 28 days of cure	0.00	35.62	0.092	6,34	0.0810
E (Cr <sub>2</sub> O <sub>3</sub> , 1.2%) - 28 days of cure	1.20	42.32	0.060	7.20	0.0420
E (Ni <sub>2</sub> O <sub>3</sub> , 1%) - 28 days of cure	1.00	31.52	0.073	5.13	0.0030
E (PbO, 0.96%) - 28 days of cure	0.96	24.96	0.051	5.10	0.0031
E (s/s-5% real waste) - 28 days of cure	5.00	18.85	0.384	4.37	0.0070
E (s/s-5% real waste) - 6 months of cure	5.00	32.43	0.053	5.07	0.0015

lead to concrete results in the delay of the initial setting time during hydration, unlike to chromium and nickel that cause a significant change in resistance of the materials. Chromium can precipitate as oxides, carbonates and sulfates, as can be substituted to calcium. Chromium and nickel give rise to new compounds that accelerate the hydration and the cement. In summary, we can be concluded that the mechanical strength of a material is characterized by the nature of the pollutant it contained (Imyim *et al.*, 2000).

The results recorded in Table 5, indicate that the materials are quartz-rich and calcium oxide. According to the XRD spectrum obtained for the cement (Fig.1), the main constituents of cement are detected at diffraction angle values different: 9 : C<sub>2</sub>S ( 2θ = 33.2° and 62,6°), 8 : C<sub>3</sub>S ( 2θ = 32,92 and

29,44 and 34.9), 10: C<sub>3</sub>A ( 2θ = 42.1) and 11 : C<sub>4</sub>AF ( 2θ = 38° and 10.15°). For the three materials based on cement CPJ (fig. 2, 3 and 4) portlandite (3: Ca(OH)<sub>2</sub>), étringite ( 3 C a O . A l <sub>2</sub> O <sub>3</sub> . 3 C a C r O <sub>4</sub> . 3 2 H <sub>2</sub> O ; 3CaO.Al<sub>2</sub>O<sub>3</sub>.3CaSO<sub>4</sub>.32H<sub>2</sub>O; 14 : Ca<sub>2</sub>Cr(OH)<sub>7</sub>.3H<sub>2</sub>O), the calcium silicate hydrates (4 : C - S - H ),chromium of calcium (13: CaCrO<sub>4</sub>.2H<sub>2</sub>O) and other phases (1: S<sub>i</sub>O<sub>2</sub>, 2 : CaCO<sub>3</sub>, 5: C<sub>6</sub>AS<sub>3</sub>H<sub>32</sub> 6 : C<sub>4</sub>ASH<sub>12</sub> 7 : Pb<sub>2</sub>Al<sub>4</sub>(OH)<sub>8</sub>(CO<sub>3</sub>)<sub>4</sub>) were detected. Thus, we detect of crystalline phases in the real and synthesized waste which contains nickel, as shown in Fig 5 and 6.

Table 5. Composition chimique

Chemical composition (%)									
	$SiO_2$	$CaO$	$SO_3$	$K_2O$	$Na_2O$	$MgO$	$Fe_2O_3$	$Al_2O_3$	other
E(C)	56.1	24.98	1.26	1.06	0.15	1.02	3.05	2.21	10.17
E(PbO)	60.9	23.15	1.32	1.18	0.25	0.62	3.21	1.98	8.01
E( $Cr_2O_3$ )	61.02	24.35	1.32	1.08	0.19	1.02	3.09	2.23	5.7
E (s/s-5%)	46,20	40,89	1.15	1.10	0.34	0.96	1,78	2,28	5.3

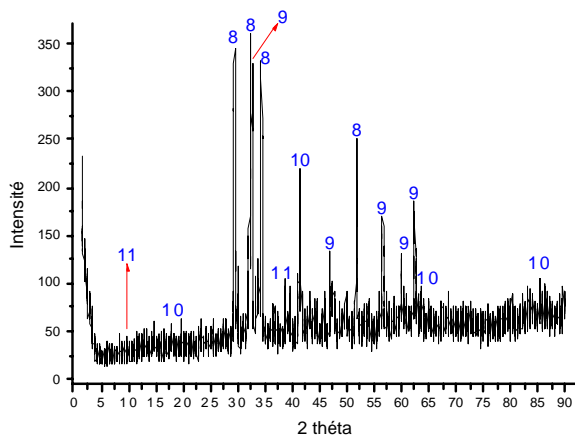


Fig. 1. X-ray diffraction of hydraulic Binder used; cement CPJ

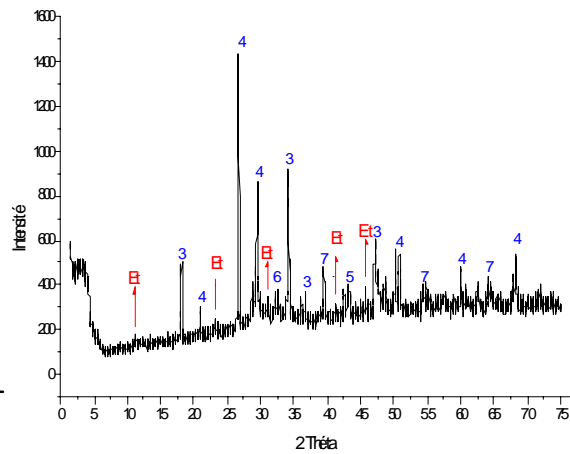


Fig. 2. X-ray diffraction of material E(PbO)

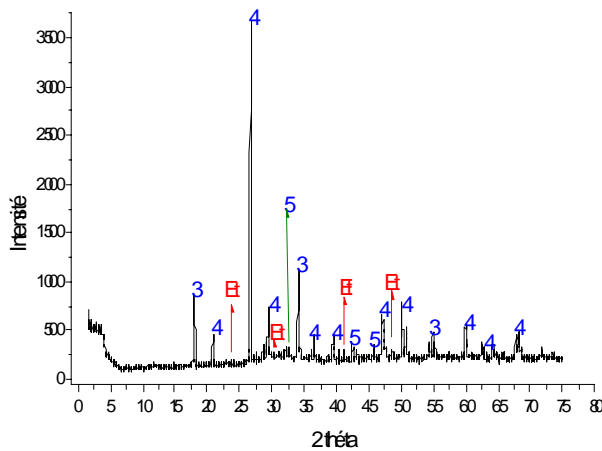


Fig. 3. X-ray diffraction of control material  $E(T)$

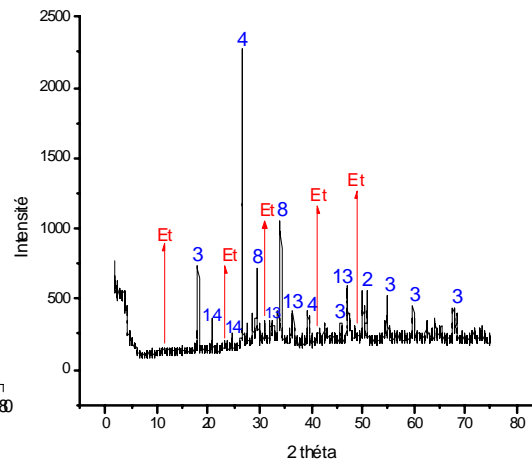


Fig. 4. X-ray diffraction of material E( $Cr_2O_3$ )

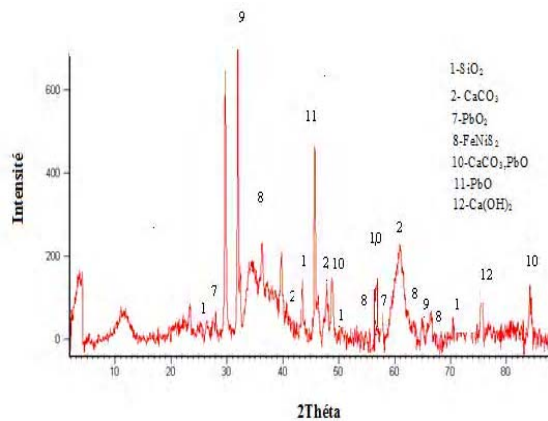


Fig. 5. Spectrum obtained by XRD of real waste

The results given in Table 6 show that the CAE and the porosity of the three synthesized materials are of the same order of magnitude. A slight difference was recorded; it is mainly due to the amount and nature of pollutants used in these materials. For cons, the material S/S contained real waste present moisture, loss on ignition, CAE and high porosity. This explains its low strength at 28 days of cure.

The results (Fig. 7) show that the natural pH of the three samples is about 12, suggesting that contact of demineralized water; the samples contain portlandite  $\text{Ca(OH)}_2$  controlling the pH in this neighborhood. For  $\text{pH} \approx 12$ , the samples obtained are basic, the basicity is due to the release of alkaline ( $\text{Na}^+$ ,  $\text{K}^+$ ) which react with the hydroxides of the leach solution to form the bases  $\text{NaOH}$  and  $\text{KOH}$ , respectively. A drop in pH is observed for materials due to the dissolution of carbonates by the following reaction:  $\text{CaCO}_3 \rightarrow \text{Ca}^{+2} + \text{CO}_3^{-2}$ , this dissolution is enhanced by the addition of acid that causes the conversion of bicarbonates ions as indicated by the following reaction:  $\text{CO}_3^{-2} + \text{H}^+ \rightarrow \text{HCO}_3^-$ . As long as there is the calcite, the pH of the system is buffered at about 6 whatever the amount of acid added. When the calcite is exhausted, the carbonate ions that are found in the form of bicarbonates react again with the added acid to form carbon dioxide according to the aqueous reaction:  $\text{HCO}_3^- + \text{H}^+ \rightarrow \text{CO}_2$ , which results the new drop in pH. The behaviour as a function of pH (Fig. 8), we can

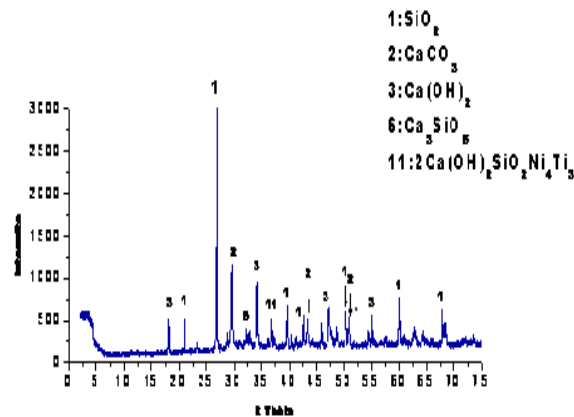


Fig. 6. X-ray diffraction of material E( $\text{Ni}_2\text{O}_3$ )

classify species  $\text{Ni}^{2+}$ ,  $\text{Pb}^{2+}$  and  $\text{Cr}^{3+}$  as species dependent on PH. The level of solubilization of lead, chromium and nickel in basic medium, for materials synthesized is similar to that in acidic medium. By cons, for the real waste, solubilization of chemical species is intense in the acid medium. This can be explained by the deactivation of the role of binder used and the complete dissolution of hydrates (in this case hydrates and mineral phases cannot fix lead, chromium and nickel). The basicity of the leach solution favors the precipitation of lead as  $\text{PbO}$ ,  $\text{Pb(OH)}_2$ , and  $\text{PbO} - \text{Pb(OH)}_2$ , it can also combine with the hydroxide ion to form a complex ion  $\text{Pb(OH)}_3$  and the salts of this complex ion is more soluble in water than  $\text{PbO}$  and  $\text{Pb(OH)}_2$ . The release of chromium and nickel appear to be controlled by the dissolution of soluble solid phases such as:  $\text{CaCrO}_4 \cdot 2\text{H}_2\text{O}$ ,  $\text{Ca}_2\text{Cr(OH)}_7 \cdot 3\text{H}_2\text{O}$  and  $2\text{Ca(OH)}_2\text{SiO}_2\text{Ni}_4\text{Ti}_3$ . The maximum amounts leached of lead, chromium and nickel are respectively about 16.44, 1.21, 3.56 mg/kg for samples synthesized and 70, 9.8, 900 mg/kg for the real waste.

The solubilization of lead, chromium and nickel (Fig. 9) increases with decreasing L/S ratio. The maximum quantities extracted, recorded, of lead, chromium and nickel are respectively about 106.4, 1.48, 21.32 mg / kg for samples synthesized and 38, 40, 80 mg / kg for the real waste.

Table 6. Physical parameters of the materials studied

Désignation	Moisture (%)	Loss on ignition %	CAE (%)	$\rho_s$ ( $\text{kg} / \text{m}^3$ )	Porosity (%)
E(T)	4.592	0.773	0.849	1,477	1.253
E (PbO)	5.561	0.772	0.870	1,486	1.291
E ( $\text{Cr}_2\text{O}_3$ )	5.539	0.780	0.869	1.401	1.235
E( $\text{Ni}_2\text{O}_3$ )	6.321	2.534	0.956	1.633	1.561
E(s/s-5% real waste)	11.23	5.320	1,211	1,570	1,900

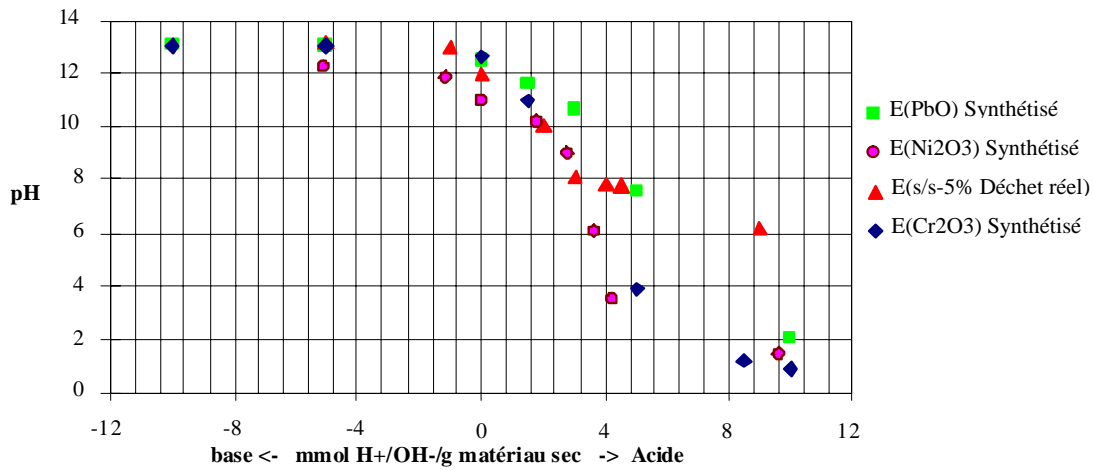


Fig. 7. Comparison of pH values †depending on the quantities of acid or base added to the materials E(PbO), E(Cr<sub>2</sub>O<sub>3</sub>) and E(Ni<sub>2</sub>O<sub>3</sub>) and E(s/s- 5% real waste)

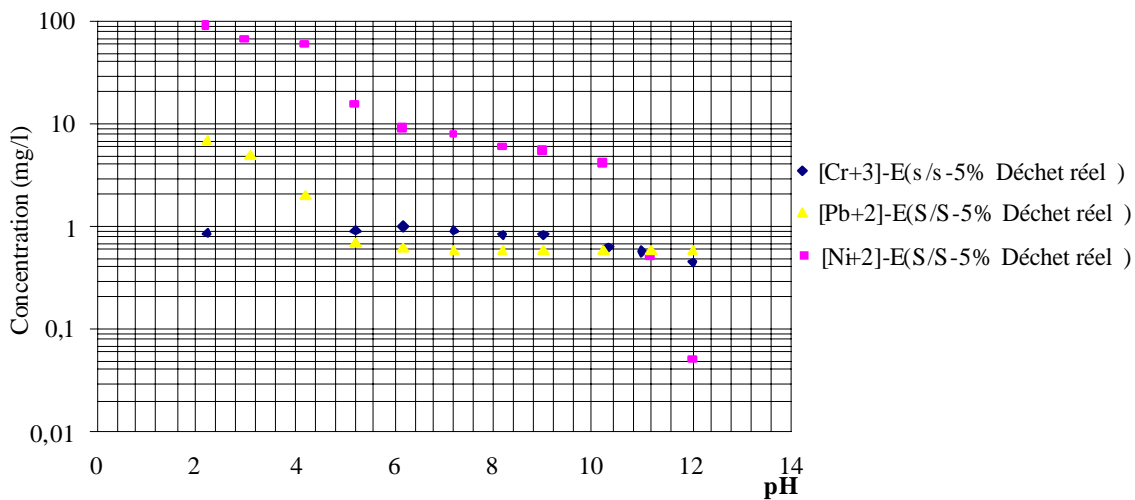
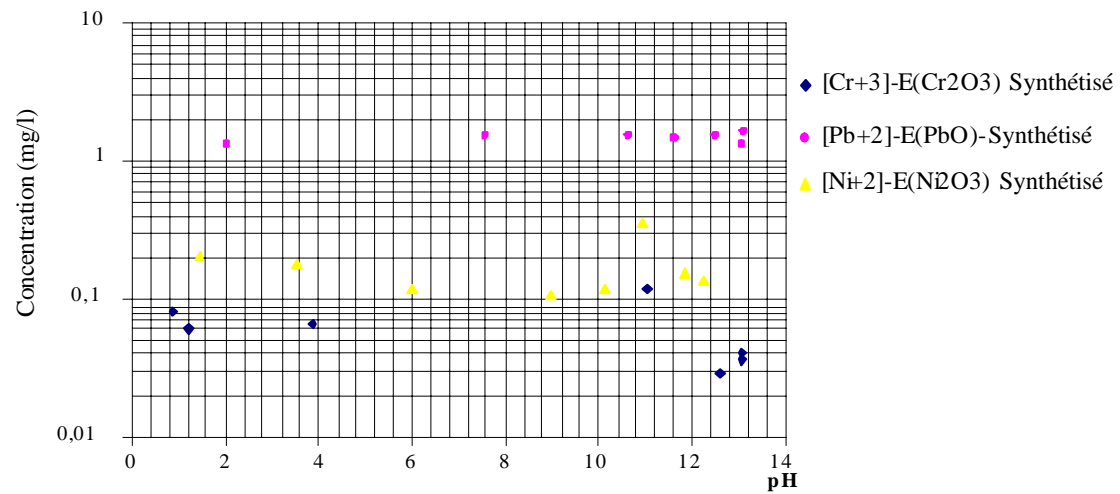


Fig. 8. Solubilization of chemical species studied depending on pH in materials s/s - E(PbO), E(Cr<sub>2</sub>O<sub>3</sub>) and E(Ni<sub>2</sub>O<sub>3</sub>) and E(s/s- 5% real waste)

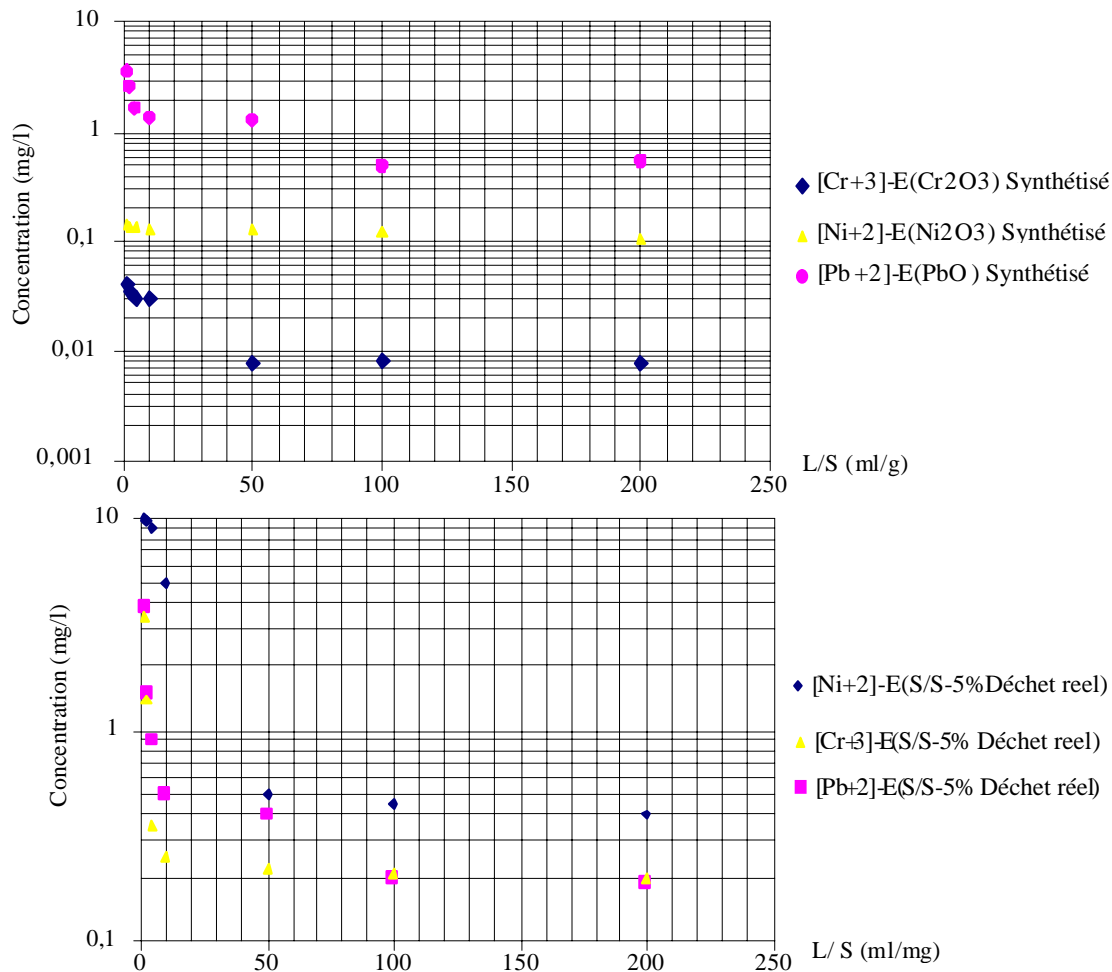


Fig. 9. Evolution in concentrations of chromium, lead and nickel according to the ratio L / S in the materials s / s

Table 7. Total flows leached of chemical species in different mediums

E(s/s-5% real waste)	Total flows leached in 64 days of leaching (mg/m2)		Ratio (Alkaline medium / demineralized medium)
	Alkaline medium	demineralized medium	
Ni <sup>+2</sup>	8,80E-03	5,46E-02	6,20
Cr <sup>+3</sup>	5,78E-03	1,69E-02	2,92
Pb <sup>+2</sup>	7,37E-03	4,63E-02	6,28

According to Fig. 10, 11 and 12 which represent the evolution of the flow release of chemical species based on the average time, there is in general an early release (first three points) diffusional type, the slope of the curve was -0.5 (Imyim *et al.*, 2000). Leached flows then decrease more rapidly due to a phenomenon of burnout of the free waste (not trapped in hydrates and mineralogical phases) in the material S/S. surface phenomena (leaching) may have an important contribution. At the end of this phase, the phenomenon of dissolution and diffusion in the porous system then controls the release of chemical species. The total flux of leached nickel is high compared to that of chromium

and lead (10, 11, 12 and Table 7), for chromium and lead are more trapped in the hydrate of hydraulic binder as for m:  $CaCrO_4 \cdot 2H_2O$ ,  $Ca_2Cr(OH)_7 \cdot 3H_2O$ ,  $3CaO \cdot Al_2O_3 \cdot 3CaCrO_4 \cdot 32H_2O$  and  $Pb_2Al_4(OH)_8(CO_3)_4$ . The flow of nickel and lead leached in an alkaline medium (Table 7) are approximately six times higher than those in the middle demineralized leached because the alkaline medium promotes dissolution of hydrates and mineral phases that have trapped the waste. The amount of nickel leached (Table 8) compared to the total content is less intense in the two environments compared to the quantities of lead and chromium.



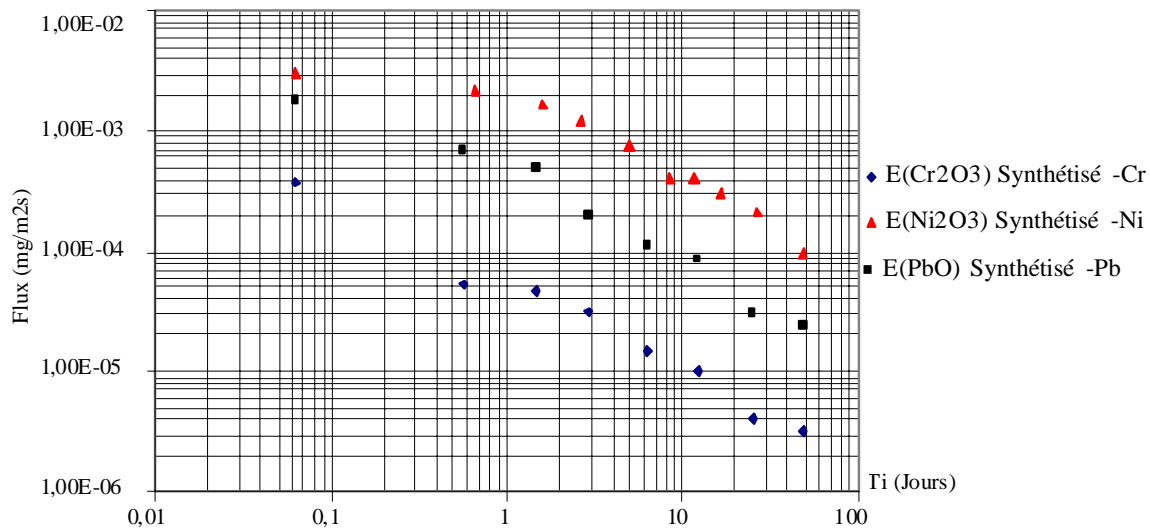


Fig. 10. Evaluation of the leaching of lead, chromium and nickel in the materials S/S, pure waste in the middle demineralized depending time

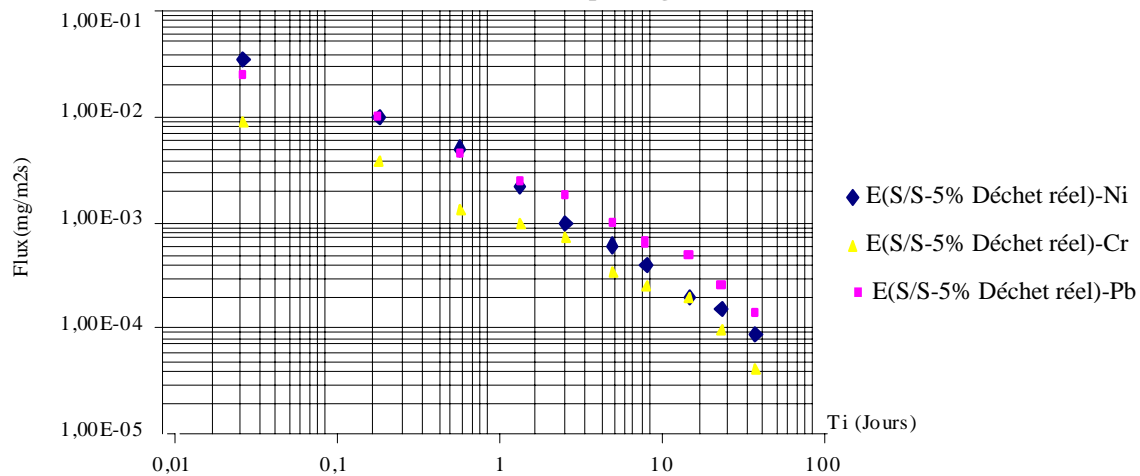


Fig. 11. Evaluation of the leaching of lead, chromium and nickel in the materials S/S, real waste in an alkaline medium depending time

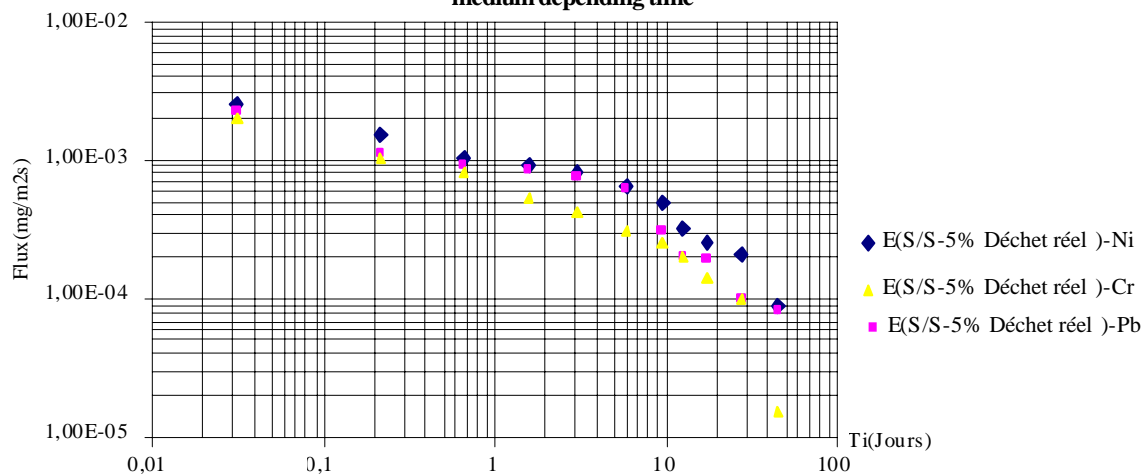


Fig. 12. Evaluation of the leaching of lead, chromium and nickel in the materials S/S, real waste in a demineralized medium depending time

Table 8. Rate of release compared to the total content

E(s/s-5% real waste)	initial concentration of chemical species precipitate (mol/l)	Amount leached in 64 days of release (mol/l)		ratio of the amount leached (%) in 64 days	
		demineralized medium	Alkaline medium	demineralized medium	Alkaline medium
Ni <sup>+2</sup>	1,23947	0,00811	0,05032	00,65	04,06
Cr <sup>+3</sup>	0,06356	0,00615	0,01797	09,67	28,27
Pb <sup>+2</sup>	0,02790	0,00197	0,01236	07,06	44,30

## CONCLUSION

Exploitation of results of applied tests on porous materials obtained by S/S processes, we afford to draw the following conclusions:

- Results of compressive strength obtained, it appears that the lead and nickel delay the setting time and chromium accelerates the setting time. It is noted that the mechanical strength of the material E (Waste s/s-5% actual) is increased from 18.23 to 32.43 MPa from 28 days to 6 months of conservation.
- The XRD analysis afford to identify the main phases presented in our materials (Portlandite, CSH), which can dissolve more or less quickly and be available or not during the leaching.
- The estimation of water absorption capacity (CAE) has to justify the reduction of exchange surface between waste and lixiviant during the leaching. The water absorption capacity of chromium is less than that of lead and nickel confirming that the material of chromium is less porous than the material of lead and nickel that the amount of chromium leached is lower than that of lead and nickel.
- The determination of the solubility of the pollutants in solution and the maximum fraction mobilized in relation to the total content allow predicting the fraction of stabilization or physicochemical retention. According to the results of FMM test, retention of nickel is important in relation to its total content.
- The amount of nickel leached in 64 days (which is equivalent to 96 years of release) that is the order of 0.65% compared to the total content of the material in the middle demineralized, demonstrates the effectiveness of the process adapted in the S/S of the waste of BCR unit by hydraulic binders.
- This low rate can be explained by the fact that nickel in the material formed a passive layer that has to resist the attacks of the aggressive medium scenario.

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