ASSESMENT OF LEACHING BEHAVIOUR TESTS OF WASTE MATERIALS USED IN ROAD CONSTRUCTION

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SUMMARY

Within the operation of research “recycling and alternative materials” of the Laboratoire Central des Ponts et Chaussées, a study was carried out by the Laboratoire Régional des Ponts et Chaussées de Saint-Brieuc to evaluate the relevance of available leaching behaviour tests to simulate the release of polluting elements resulting from a waste used in a road scenario. The main parameters likely to bring closer the conditions of the up-flow percolation test (CEN/TS 14405) of more specific conditions of a road scenario were evaluated. The Liquid/Solid ratio and the level of initial compaction of the sample showed a small influence on the polluting element release of the studied waste (polluted gravel concrete).

According to the results of the experimentation of the instrumented road RD 767 (capping layer made up of Municipal Solid Waste Incinerator Ash), the test of percolation in its standardized “standard” version (with L/S day = 0,5) constitutes a relevant test to simulate the kinetics of at least short-term release (L/S cumulated < 2) of metallic elements (Cu, Pb). A more important experience on instrumented sites will be necessary to evaluate the relevance of this type of method for an approach “middle to long term” release.

For the longer term release approach, the more easily accessible leaching test (NF X31-210/IN 12457-2) allows to obtain release close to the results obtained by the percolation test. This “compliance” test should not thus inevitably be rejected for a simulation of release, at least in a road scenario.

1. INTRODUCTION

The use of waste in public works contributes since many years to the safeguarding of the nonrenewable natural aggregate resources. The use of waste can not be considered without securing that the road work will not be at the origin of a release of polluting elements incompatible with the environment. For that the leaching behaviour of the waste has to be determined in its scenario of exposure. If the determination of this leaching behaviour has a methodology standardized in Europe [(1)], its application remains dependent on test methods nonspecific to one scenario of exposure.

The Laboratoire Central des Ponts et Chaussées launched, within the framework of the operation 11D022 “recycling and materials alternative”, a research task to assess the relevance of tests experimental or already standardized to determine leaching behaviour of a waste used in a road scenario.

On the basis of protocol first percolation test produce by the CEN/TC292 “characterization of waste”, a procedure which wants to be more representative of the conditions to which a waste is submitted in a road scenario was proposed and evaluated by the Laboratoire Régional des Ponts et Chaussées de Saint-Brieuc. The results obtained were put in parallel with the release obtained from a road made up of Municipal Solid Waste Incinerator Ash. This road has been instrumented specifically to follow in flow and concentration the percolation waters.

2. PARAMETERS INFLUENCING THE LEACHING BEHAVIOUR OF WASTE

The physicochemical agents likely to intervene in the mechanisms of mobilization and transport of polluting elements of a waste are numerous. Through the vectors such as the liquid, gaseous and solid media, these agents will interfere in the stability conditions of the major elements and the minority species contained in waste.

The leaching behaviour of granular waste is mainly controlled by the solubility of the species, for what concerns the mobilization of the polluting potential and by the convection (soluble elements are transported in the movement of the fluid), for what concerns transport the polluting potential [(2)].

Through the application of a Liquid/Solid ratio (L/S) to the waste sample, the mechanisms of solubility and convection are used to simplify and accelerate the release process of polluting elements of a granular waste and to lead to a simulation test of leaching behaviour that can be used in accordance with the spirit of methodological standard the “for the determination of leaching behaviour of waste under specified conditions” (EN12920: 2006).

3. TESTS FOR THE DETERMINATION THE LEACHNING BEHAVIOUR OF WASTE

The tests which can be used to determined the leaching behaviour of waste are gathered in the two following categories :

- “Basic characterization” tests which are used to identify the intrinsic characteristics of the waste and the influence of parameters (ratio Liquid / Solid, pH,…) on its short and long term behaviour. Among these tests one can quote the percolation test which was standardized in 2004, on the basis of specific conditions which do not represent a specific scenario of exposure (CEN/TS 14405: test of percolation to ascending flow).
- “Compliance” tests which are used to check that waste respects reference thresholds imposed by utilisation. These “simplified” tests use a small number of parameters which act on the leaching behaviour. These parameters are sufficiently severe (fragmentation, high Liquid / Solid ratio, agitation), to generate important release which can be obtained after a long term exposure. Among these tests one can quote the “leaching” test” initially standardized in France under the reference NF XP 31-210 and which was transposed at the European level under the reference EN 12457-2.

The principle of the first draft percolation test, proposed by CEN/TC292 in 1997 (with its adaptable Liquid/Solid ratio), was used to propose a simulation test as close as possible to the hydrous conditions encountered by a waste in a road scenario.

4. ADAPTATION OF PERCOLATION TEST TO A ROAD SCENARIO

4.1. Hydrous characteristics of the road scenarios

The principal characteristics of the hydrous transfer in a road scenario are described below [3].

— A fast variation of the hydrous conditions (water content, volume of percolation waters,…) is noted in the layers of roads after each rainy event.
— This variation of the water content in the materials, during various climatic cycles, is more important as one approaches the road surface.
— The transfers of water under the bituminous mix can induce levels of water saturation, at the interface of two layers (sub base, capping layer,…).
— The L/S ratio which can be measured on sites are very variable, according to the nature of the structure and the geographical position of the road: 1,0 10^{-6} < L/S day < 1,0 10^{-4}.

Tableau 1 – example of L/S ratio obtained on various instrumented roads

Main constituent of road	Surface of the instrumented road (m^2)	time (months)	Average L/S day
MSWIA [3]	160	75	9,3 10^{-5}
Natural Gravel [3]	160	75	1,1 10^{-4}
Ash gravel [3]	100	13	1,8 10^{-6}
MSWIA [4]	150	20	9,1 10^{-5}

4.2. Caractéristiques de l'essai de percolation simulée adapté à un scénario routier

The parameters whose influence on the release of polluting elements of waste have been studied are the following

— Liquid / Solid ratio : from 0,05 to 0,5. The value of 0,05 is the weakest proposed in the initial project of CEN/TC292. It is sufficiently weak to approach, of the very slow speed of percolation observed on sites and sufficiently high to accelerate the mechanisms of solubilization and transport.
— Density : from 1,5 to 1,9. This value corresponds to a usual density obtained on site for granular material used in capping layer.

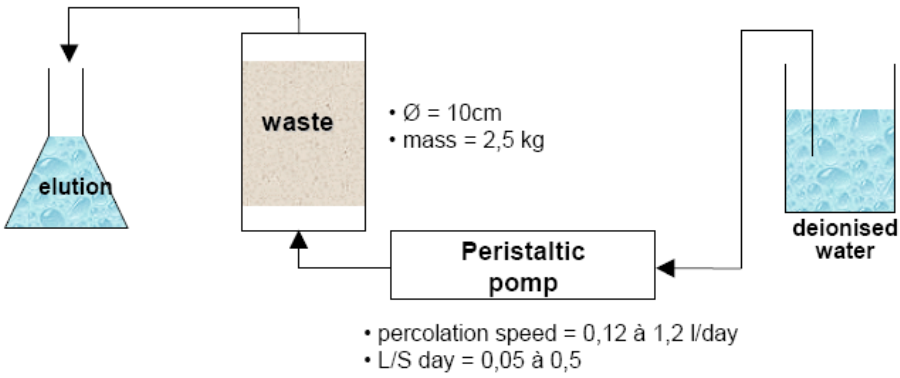

Figure 1 – principle of percolation test

Tableau 2 – comparison of percolation tests : standardised procedure (NF CEN/TS 14405) and "adapted" procedure to road scenario

	"Adapted" procedure to road scenario	"standardised" procedure (NF CEN/TS 14405)
masse / volume sample	around 2,3 kg	30 cm in 5 layers
Diameter of colomn	10 cm	5 ou 10 cm
compaction (mass dame)	density = 1,5 to 1,9 (3,7 kg)	- (0,5 kg)
Initial saturation	3 jours	3 jours
Speed of percolation (L/S ratio / day)	0,125 to 1,2 l/day (0,05 à 0,5)	1,1 l/day
number of extractions (L/S)	4 to 6 (0,3; 1; 3; 5; 10; 20; 30)	7 (0,1; 0,2; 0,5; 1; 2; 5; 10)
Duration of test (L/S=10)	20 to 200 days	30 days

5. RESULTS OF RELEASE SIMULATION TESTS

5.1. Choice of waste

The waste was chosen according to nature of polluting potential, which has to be stable all trough the duration of the test (up to 6 months). A pesticides (Hexachlorocyclohexane) polluted concrete materials were chosen. The β-HCH which is stable in alkaline medium constitutes the main element, with low solubility, which has been studied. As no road has been built with theses polluted concrete materials, simulation release tests were also practised on Municipal Solid Waste Incinerator Ash, in spite of their unstable nature (phenomenon of maturation), in order to establish a comparison with the results obtained on a specifically instrumented real roadway, whose capping layer consists of MSWIA (see paragraph 6).

5.2. Results

The simulation of polluting element release out was evaluated through the two procedures of the percolation test ("standardised" and "adapted" to the road scenario). These results are compared in the graphs below with those obtained from the "leaching" test initially standardized in France under reference NF XP 31-210 (10, 20, 30).

1.1.1 *Influence of the Liquid / Solid ratio*

— For the low solubility species (ex: β-HCH): the extracted quantities are dependent on the type of extraction (leaching / percolation), but remain linearly dependent on L/S ratio (see figure 2). The leaching test of allows to extract the largest quantity from β-HCH.

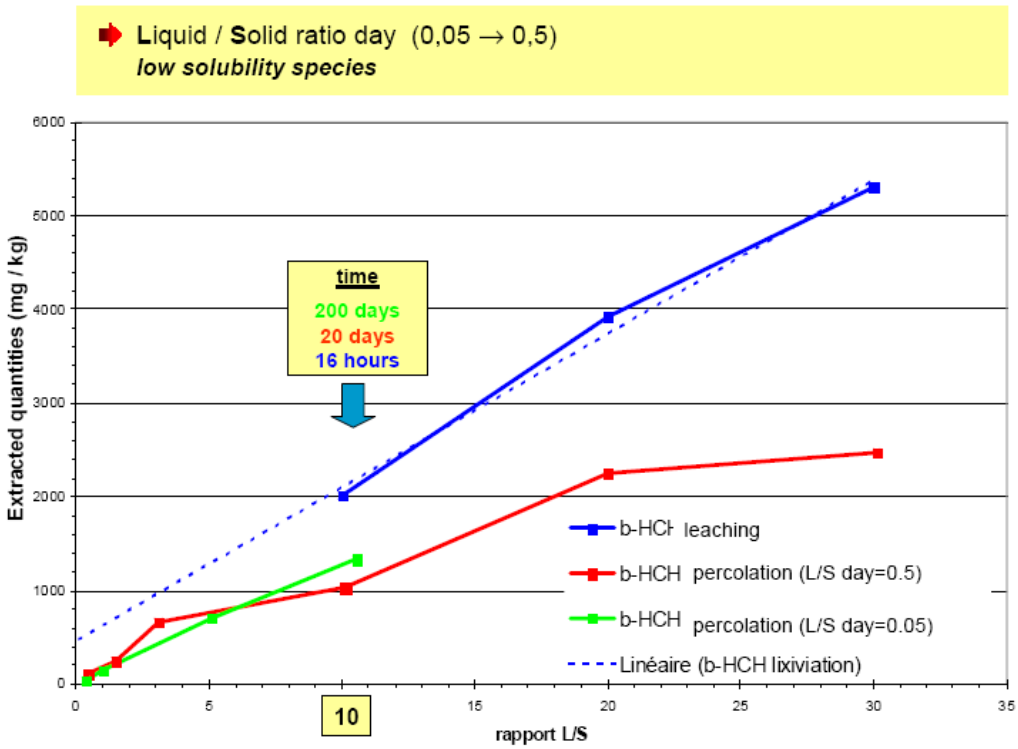

Figure 2 – influence of the L/S ratio on the leaching of β-HCH

— For the fairly soluble species (ex: sulphates): the cumulated extracted quantity is rather dependent on the technique and the conditions of extraction. The extracted quantities are more important with a low speed of percolation (see figure 3).

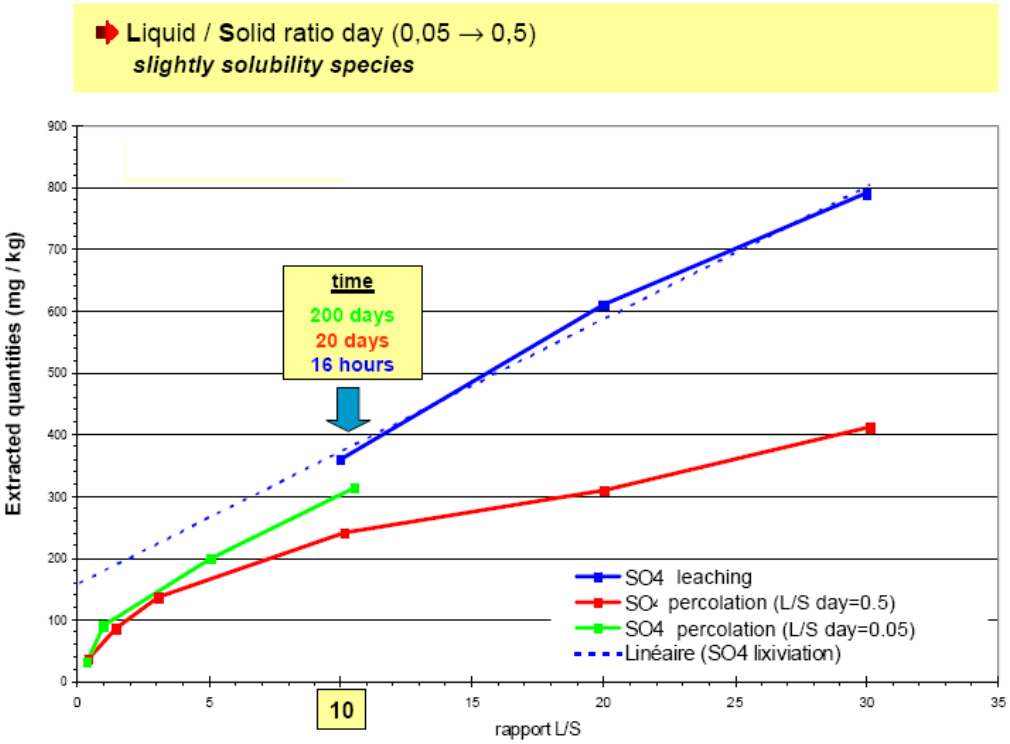

Figure 3 – influence of the L/S ratio on the leaching of sulphates

— For very soluble species (ex: chlorides) the release obtained for Liquid / Solid ratio = 10 is rather independent on the technique and on the conditions of extraction (leaching /

percolation). The variation between results is lower than 10% of the average value (see figure 4).

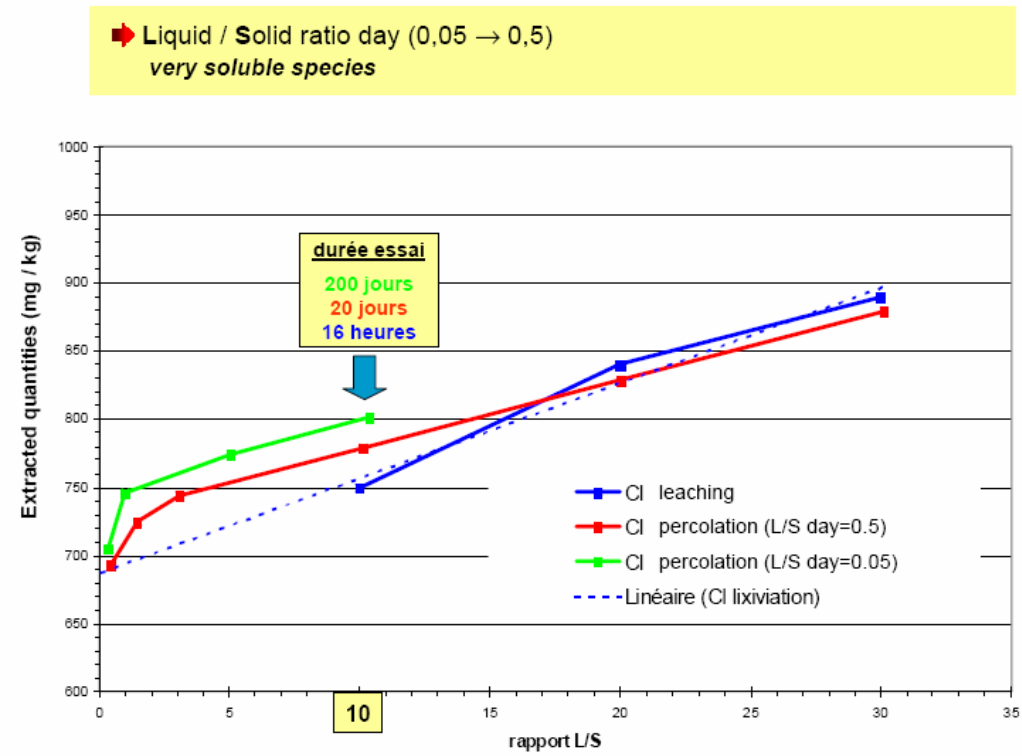

Figure 4 – influence of the L/S ratio on the leaching of chlorides

1.1.2 *Influence of density*

The results obtained show a moderate influence of the density of the sample on the release of low soluble elements (see figure 5). It should be noted that rather quickly the column made up of abounded materials (density 1,1) had reached under the influence of the water circulation a density of 1,5.

1.1.3 *Synthesis of results obtained with leaching simulation test*

Independently of solubility of the studied species, one notes that a good linearity of the release is obtained with leaching tests. For the percolation test, the linearity is obtained only for the low solubility species (β-HCH). The cumulated extracted quantities reach rapidly an asymptote for very soluble species (chlorides).

The variation between results obtained by leaching and percolation tests, for a Liquid / Solid ratio = 10, is relatively low from 10 to 100% and similar to the repeatability announced for this test method (EN 12457-2).

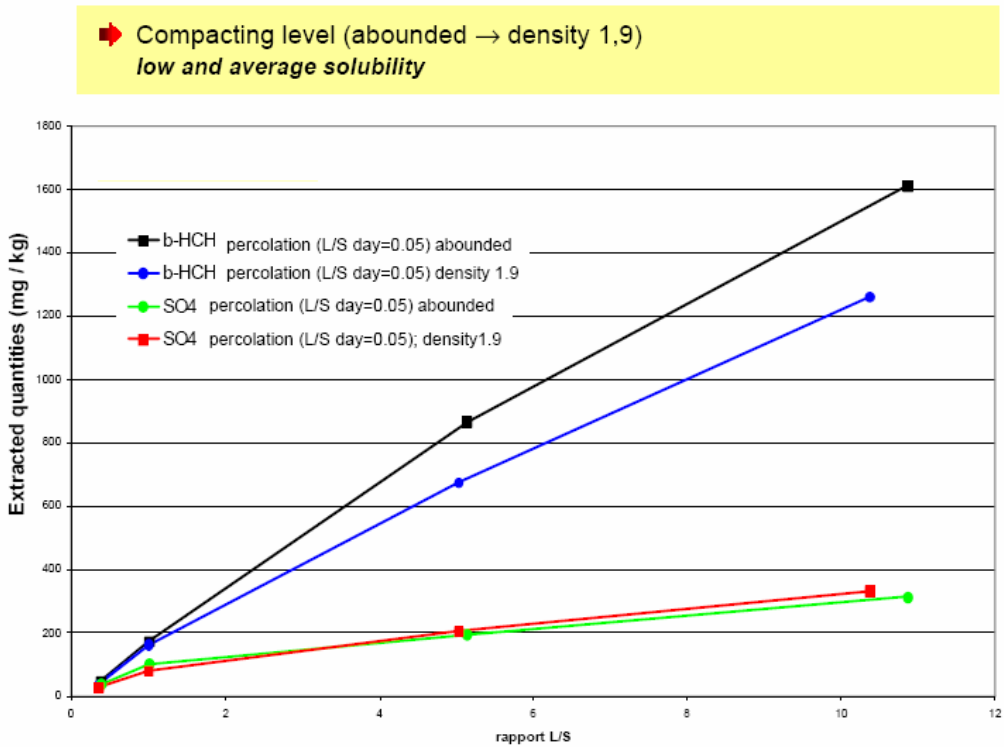

Figure 5 – influence of compaction on the leaching of β-HCH and sulphates

6. COMPARISON BETWEEN SIMULATION LEACHING TEST AND INSTRUMENTED ROAD RESULTS

To evaluate the leaching simulation test ("leaching" / percolation) with respect to the release obtained on site, a road made up of Municipal Solid Waste Incinerator Ash (RD 767 - Bégard - Côtes d'Armor), was instrumented to collect the percolation waters and to thus determine release flux of polluting elements (see figure 6).
The instrumented road is made up of 153 tons of MSWIA, coming from the Incineration plant of Pluzunet, was studied from October 2002 to June 2004. The volume of water collected (86 m3) represents about 35% of the pluviometry raised during the 20 months of the period. This value (one of highest obtained on this type of instrumented roads) corresponds to a Liquid / Solid ratio of 0,56. It can be partly explained by the period during which the proofing of the roadway was not assured.

The release of the metallic species (copper and lead) obtained on site at the end of the 20 months of the study correspond between 24% (Pb) and 33% (Cu) of the quantity extracted by the leaching test NF X31-210: L/S = 10 (see figures 7 and 8 - sample n°1).
As the percolation test was practised after the construction of the road a second sample on MSWIA has being made up coming from the same incineration plant (sample 2). The leaching tests practised on this sample 2, show a release more important for lead and weaker for copper compared to sample 1.

Figure 6 - implementation of the sealing and the MSWIA – RD767 instrumented roadway

In spite of this difference on the metallic element release potential, one notes that the quantities extracted from lead and copper follow the same kinetics as those observed on the instrumented site. One notes for copper a good correspondence between the results obtained by the percolation test and those obtained by the leaching test, for a L/S ratio =10. For lead, the results of obtained by the leaching test remain definitely higher than those obtained by simulated percolation.

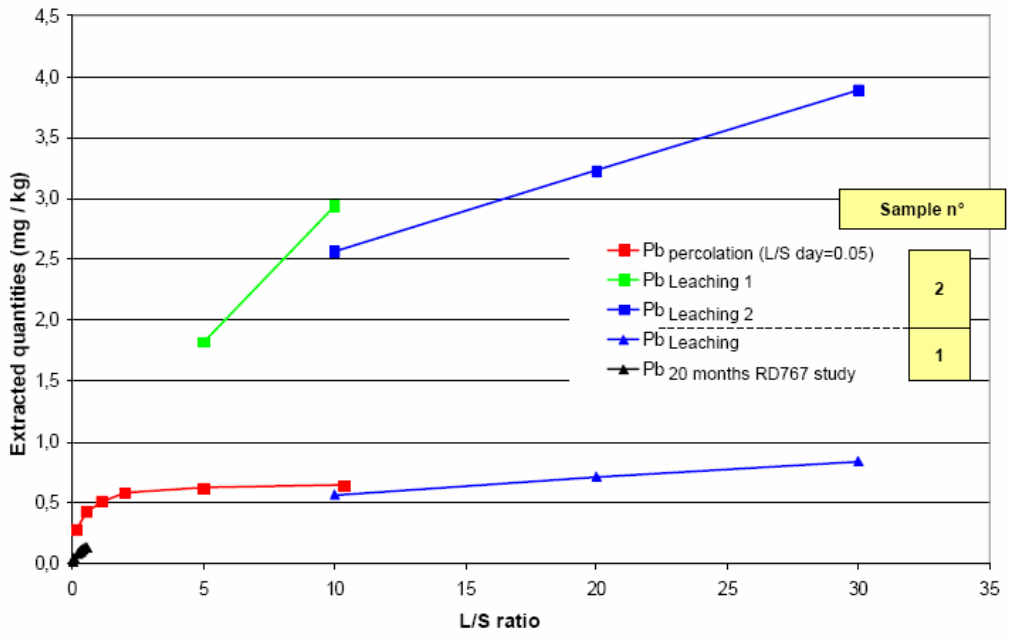

Figure 7 - comparison between release obtained on RD767 instrumented site and leaching simulating tests (lead)

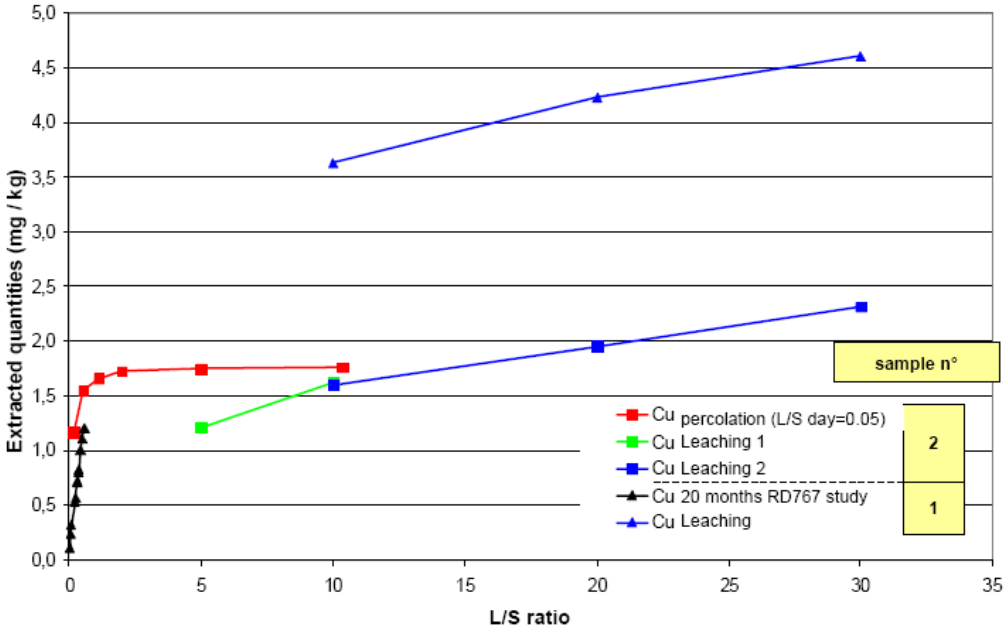

Figure 8 – comparison between release obtained on RD767 instrumented site and leaching simulating tests (copper)

7. CONCLUSION

The environmental characterization of waste can be done through the use of a methodology and of test methods now standardized at the European level. The testing methods available, “compliance” tests (“leaching” test) or “basic characterization” (percolation test), were not conceived to simulate a specific scenario of exposure. The principal parameters likely to bring closer the conditions “standard” the test of percolation standardized (CEN/TS 14405) of the more specific conditions of a road scenario were evaluated.

The fall of the Liquid / Solid ratio (L/S day = 0,5 → 0,05) which was practised to approach the conditions observed on instrumented roads, showed a small influence on the release of very soluble to slightly soluble species present in the waste. It is the same for the initial compaction for the sample.

According to the results of the instrumented road (RD 767 - made up of Municipal Solid Waste Incinerator Ash), the percolation test in its standardized version (with L/S day = 0,5) constitutes a relevant test to simulate the kinetics of at least short-term release (L/S cumulated < 2) of the metallic elements (Cu, Pb). A longer experience on such instrumented sites will be necessary to evaluate the relevance of this type of method for a “long term” release approach.

For the longer term release approach, the more easily accessible leaching test (NF X31-210/IN 12457-2) allows to obtain release close to the results obtained by the percolation test. This “compliance” test should not thus inevitably be rejected for a simulation of release, at least in a road scenario.

The authors thank the Conseil Général des Côtes d’Armor (MM. Leweurs, Sulpice) to have allowed the realization of the environmental study of experimental instrumented road RD 767.

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