Sétra

Service d'études sur les transports, les routes et leurs aménagements

# Impact of Road Salts on the Mobility of Metals in Contaminated Urban Ground Fill

XIII INTERNATIONAL WINTER ROAD CONGRESS

Ressources, territoires, habitats et logement
Énergie et climat
Développement durable
Prévention des risques
Infrastructures, transports et mer

Présent pour l'avenir

***Quebec, February 8 – 11, 2010***

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Ministère de l'Écologie, de l'Énergie, du Développement durable et de la Mer

## *Where do urban “contaminants” come from?*

**From the “road”**

**Treatments**
**NaCl, etc.**

**Vehicles**

Spattering

**Brakes**
**Zn, Pb, Cr, Cu**

**Zn, Cd**

**Exhaust**

**Zn**

Runoff

**Road equipment, etc.**

## *Where do urban contaminants come from?*

**From snow itself, which picks up “contaminants”…**

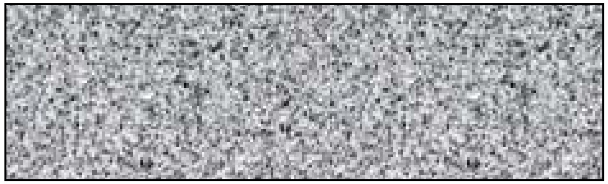
**...when snow is picked up, contaminants are also picked up.**

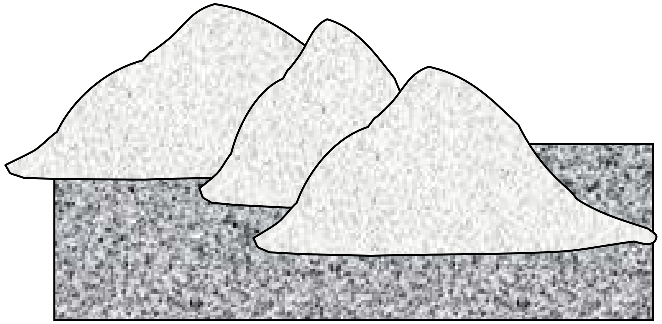
## *Where do urban contaminants come from?*

**Materials in the surroundings (from industrial processing, steel mills, chemical plants, etc.)**

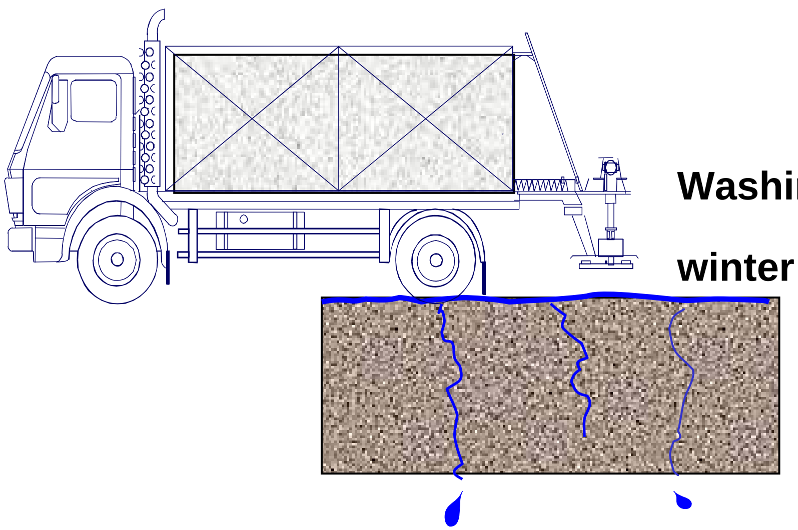
**Contaminated fill**

**Snow storage platform with contaminated materials**





# *What happens to “contaminants”?*

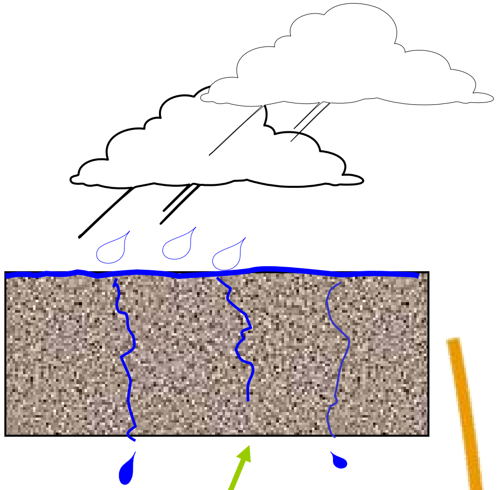


**Washing of brines from**

**winter servicing**

**Washed off with**

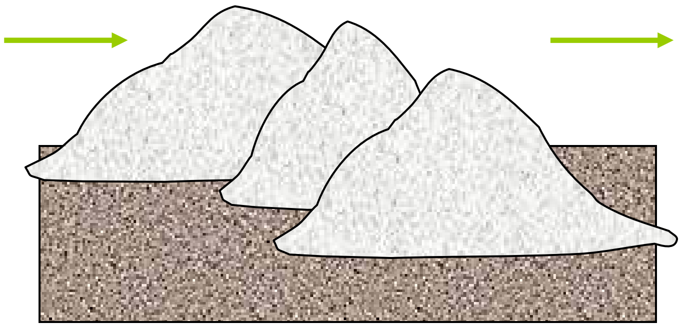
**rain water**



**Contaminated urban fill,**
**industrial wasteland,**
**Contaminated platform**

**Storage of snow salted with “contaminants”**

**Washed off during melting**



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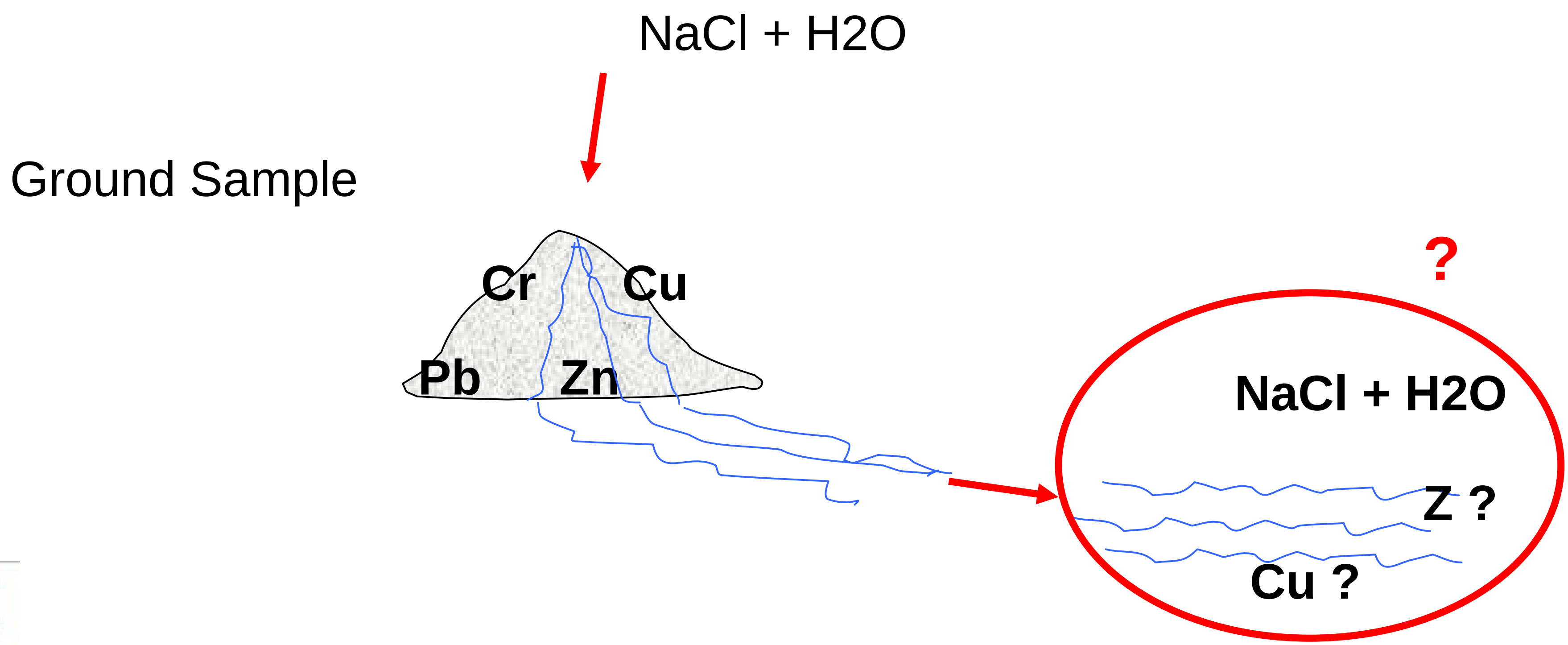
# *Study goals and method used*

The aim was to study the relationship between the concentration of salt applied to contaminated ground, on the one hand,  and the amount of “re-mobilized” metal in aqueous phases, on the other.



# Study goals and method used

**The aim was to study the relationship between the concentration in salt applied to contaminated ground, on the one hand, and the amount of re-mobilized metal in the aqueous phases, on the other.**

| ***Goal*** | ***Parameter Studied*** |
|---|---|
| Study the behavior of ground from urban fill and from industrial wastelands and evaluate the impact of the degree of contamination | Tests performed on two types of ground samples from:<br>- Urban fill contaminated with different metals;<br>- Industrial wastelands with heavy contamination of a particular metal |
| Make a simple evaluation of ground behavior and the mobility of metals over time | Variation of the ground/solution ratio |
| Estimate the amounts of mobilized metals in the aqueous phase according to NaCl concentration | Variation of NaCl concentrations |
| Compare the effect of $NaCl$ and $CaCl_2$ | Two salts tested: $NaCl$ and $CaCl_2$ |

## *Method used*

Using a static mode approach and “batch testing”, the principle is to mix the ground to be analyzed with a solution of NaCl (shake, mix, filter, centrifugate: the whole process…).

Next, the solution is analyzed with a plasma emission spectrometer (ICP-OES) that enables establishing the amount of different bodies present, in particular heavy metals.

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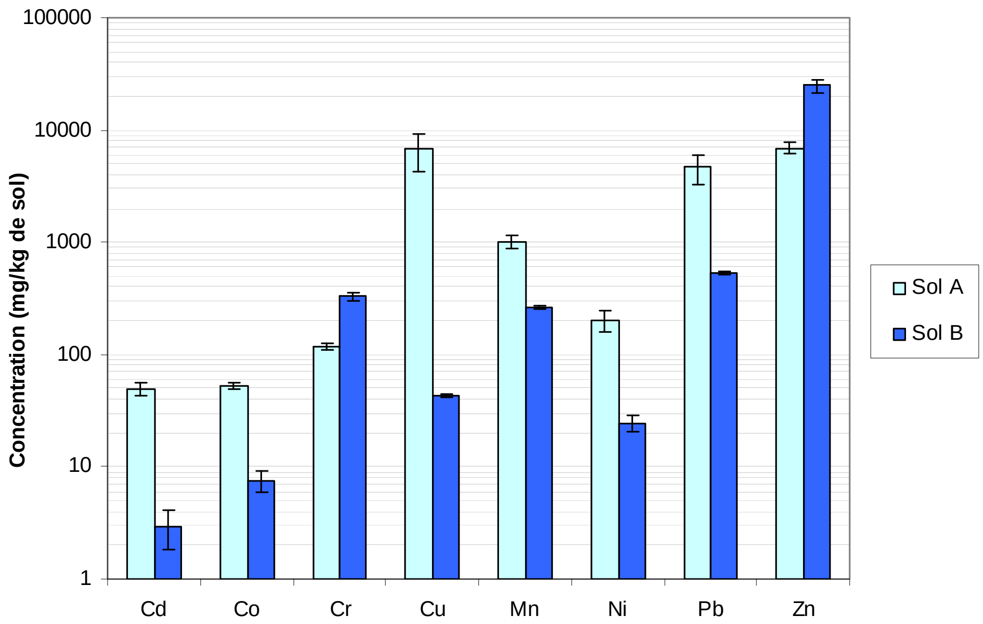
# *Results*

Grounds taken from the different sites under study showed heavy metal concentrations well above regulatory limits…




| | Cd | Co | Cr | Cu | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|
| Ground A | 49,8 | 52,6 | 117,4 | 6 720 | 1 004 | 202 | 4 646 | 6 883 |
| Ground B | 3,0 | 7,6 | 327,0 | 43 | 259 | 25 | 530 | 24 875 |
| Regulatory Amount | 5,0 | 50,0 | 250,0 | 100 | 1 000 | 100 | 500 | 500 |

**Metal amounts in the two types of ground and regulatory threshold values in Quebec (in mg/kg of ground)**

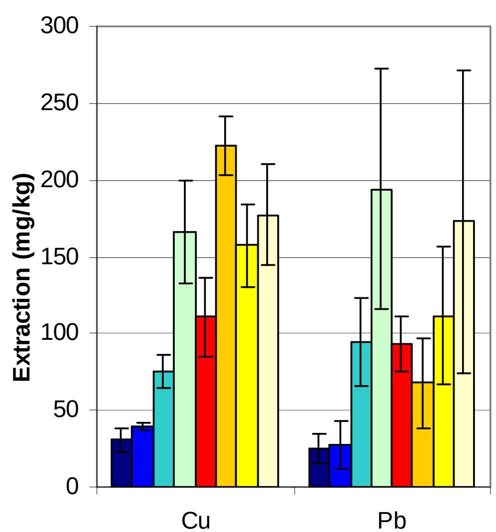
# Results

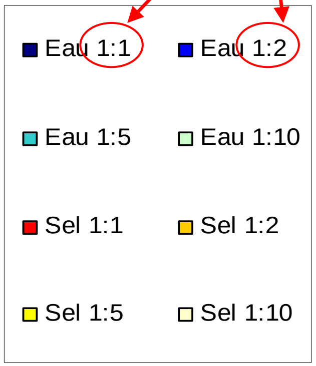
*Influence of variations in ground/solution  ratio (washing with distilled water and a 1 mol/L saline solution)*

The quantity of metal extracted from the ground (Ground A) decreases when the ground/solution ratio increases

The more the ground is washed, the greater are the quantities of metal “released”

**Ground/solution ratio**



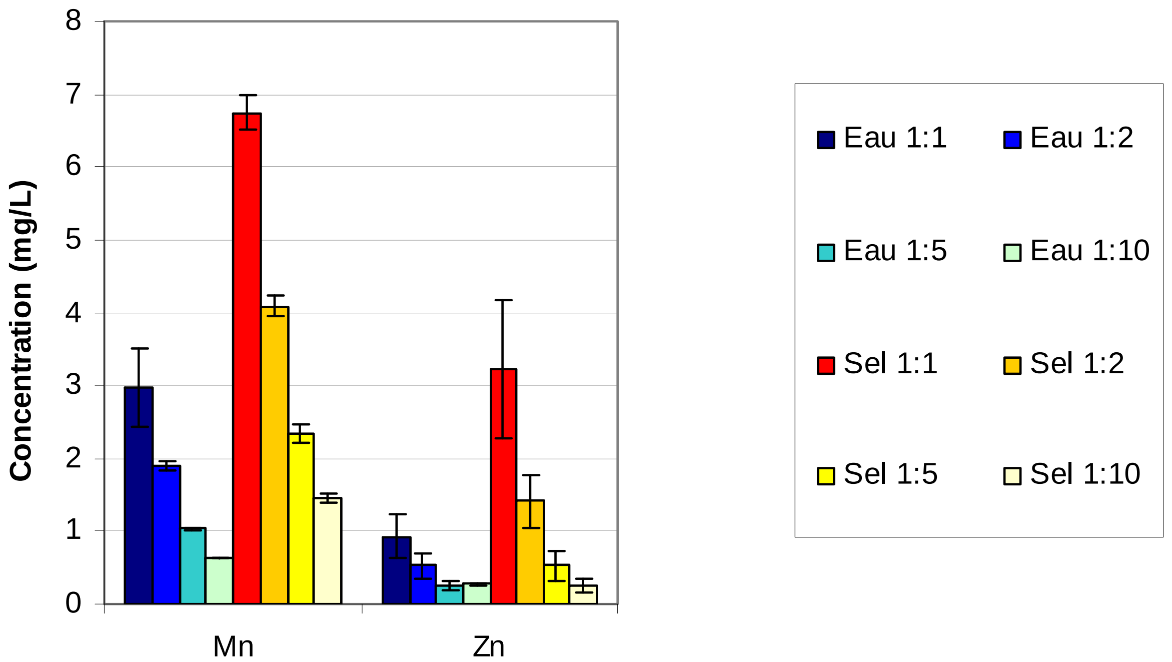




**Example of extracted quantities of Pb and Cu**

# Results

*Influence on the concentrations of metals released into the solution when NaCl concentration is varied*

Contrary to what is observed for the extraction of metals from the ground, the metal concentrations in solutions obtained are higher for the larger ground/solution ratios: the volume of water is less and the ground mass is greater



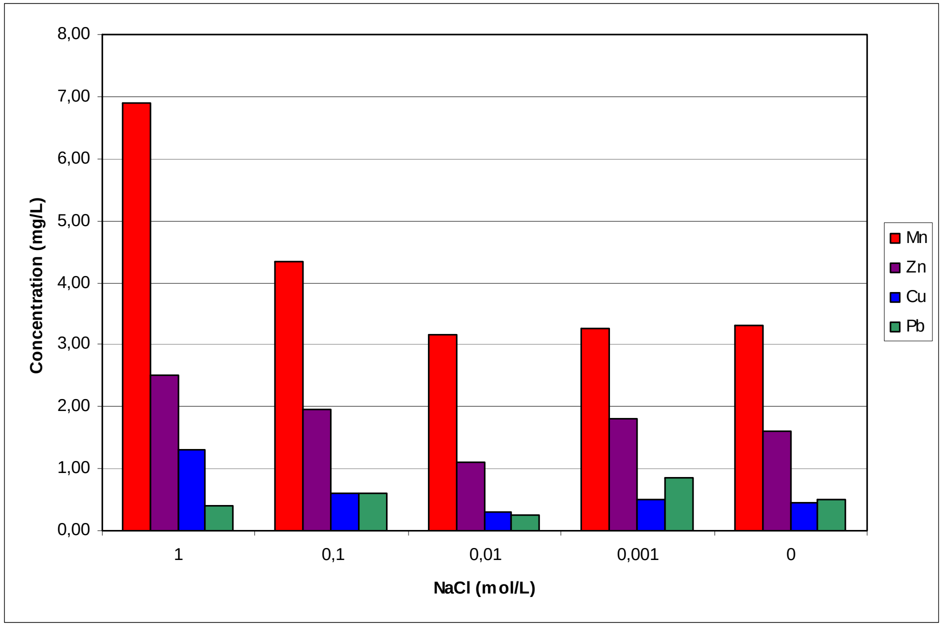

**Example of Mn and Zn**

# Results

*Influence of variations in NaCl concentration*
*Tests from 0.001 mol/L to 1 mol/L ( 58 g/L)*

The quantity of Mn, Zn and Cu mobilized when the solution is added tends to decrease with a higher concentration of NaCl and attains a plateau around 0.01 mol/L.

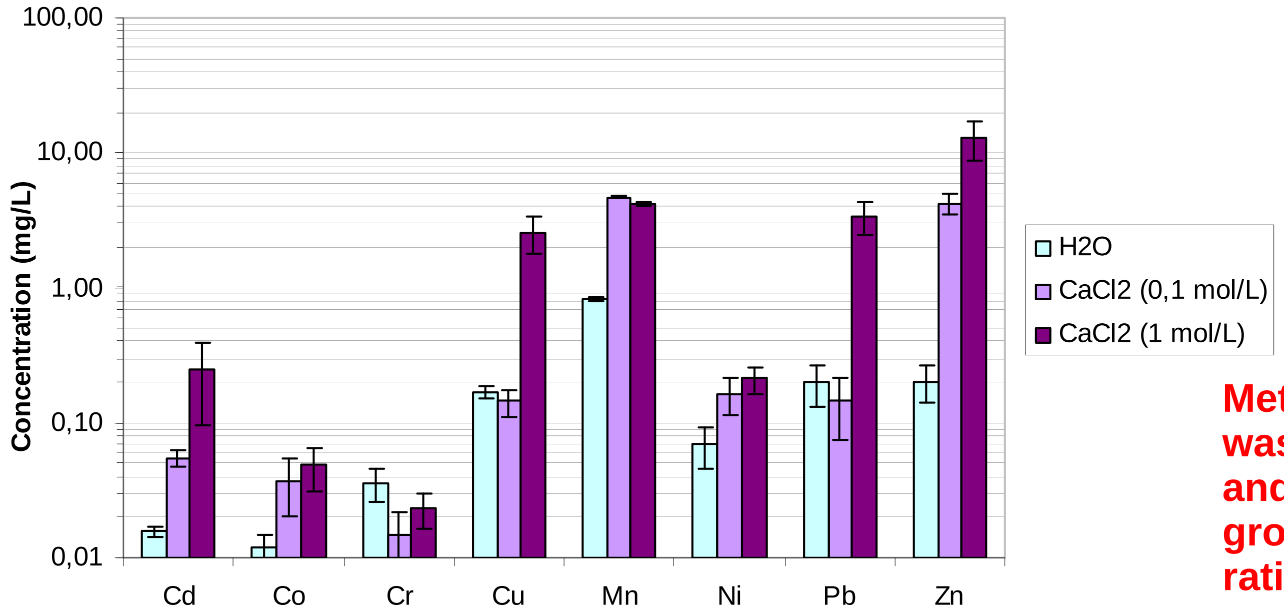
High concentrations of NaCl thus stimulate the re-mobilization of metals present in the ground, whereas for weaker concentrations (< 0.01 mol/L) there is no clear difference. Lead concentration alone does not vary with an increase in salt content.



# Results

*Influence of variations in CaCl2 concentration*

For certain metals, the addition of calcium chloride leads to much greater amounts of metal than the addition of distilled water. The greater the ratio of ground to solution, the larger are the amount of metals released into the solution.



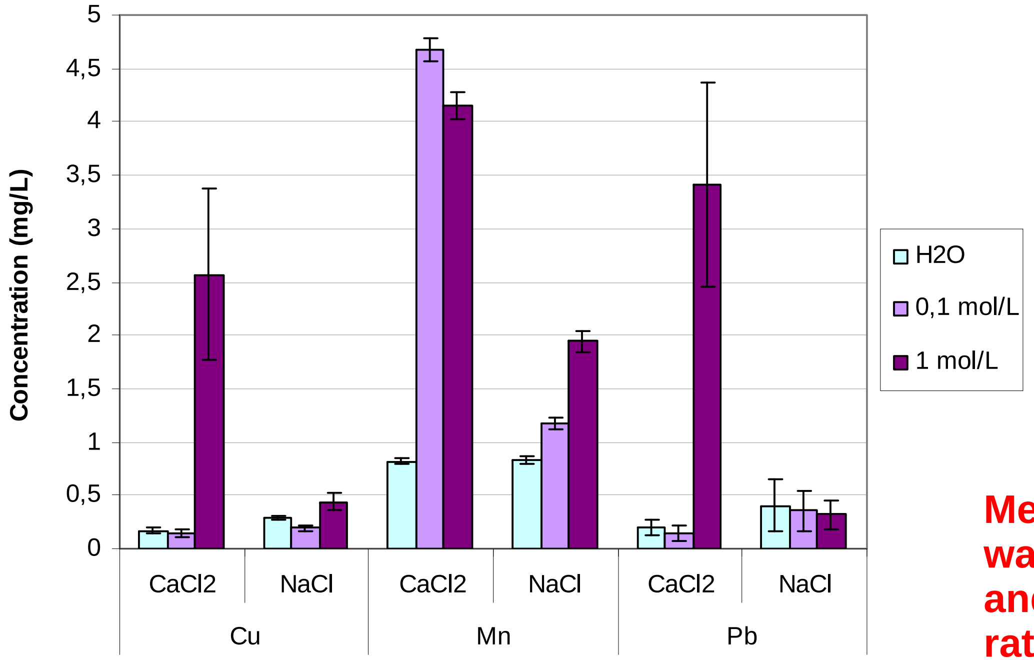

**Metal contents after washing with water and $CaCl_2$; ground/solution ratio is 1:5.**

# *Results*

## *Comparison  between NaCl and CaCl2*

The quantities of Cu and Pb released into solution during washing with salt at
0.1 mol/L are largely the same with $CaCl_2$ or NaCl.

With a concentration of 1 mol/L, values are different for the two salts and the amounts of Cu, Mn and Pb in solution are from two to ten times higher than with $CaCl_2$




**Metal contents after washing with water, $CaCl_2$ and NaCl; ground/solution ratio is 1:5.**

# Study conclusions

The mechanisms entering into the capture or “re-mobilization” of “contaminants” are highly complex.

It is relatively difficult to model the phenomena that occur: concentration of the products, quantities of water, ground compactness, speed of flow, etc.

Metals associated to residual materials are not necessarily stable; they can be “re-mobilized” by water and even more so by saline solutions.

The ratio of ground to solution is important. The larger the volume of water in proportion to the ground mass, the greater the surface of exchange and the easier it is for desorption mechanisms to occur.

# *“Winter Service” conclusions that we can establish from the findings of this study*

During salting operations, we must pay attention not only to ecologically sensitive areas (protected areas, etc.), but to other areas as well.

The more polluted an area is, the more it will generate pollution!

Attention must be paid to avoid storing snow in urban areas and on non-polluted material platforms, as well as to specific measures (e.g., carrying out brine de-concentration in basins and avoiding stress phenomena).

Certain road sites are monitored (LR St Brieuc, LCPC); it might be interesting to “salt” them.

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Cette étude a été réalisée par Julie Ternisien, aujourd’hui décédée, dans le cadre d’un DESS en génie de l’environnement à l’Ecole de Technologie Supérieure de Québec suivi par Jean-Sébastien Dubé

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