MONITORING HYDROGRAPHS AND POLLUTOGRAPHS IN THE RUNOFF WATERS ORIGINATED FROM ROAD DEICING SALTS

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CLEAN ROADS

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INTRODUCTION:

The spreading of chemical de-icing salts on the road surfaces is a common practice in winter season. De-icing salts are based on sodium chloride, which is extremely soluble, releasing Na^+ and Cl^- which are transported by surface runoff. This results in a significant increase in the salinity of soils, groundwater aquifers and surface water bodies, with the risk to approach the levels associated with negative effects on aquatic and terrestrial ecosystems.

Potential impacts are chronic effects on biota, decrease in biodiversity, enrichment of salt-tolerant and invasive aquatic species and contamination of potable water supplies.

Once contaminated by de-icing salts, and in particular by high chloride levels, surface and groundwater may require decades, if not longer, to recover.

An accurate site-specific monitoring of runoff water quality represents a key requirement to improve the management of de-icing salts spreading, reducing the consumption.

MATERIALS AND METHODS:

Rainfall and snowfall events (27 events) were monitored during three winters (2013-2016).

Equipment for runoff water monitoring

1) rain gauge and radar for detection of rain or snow
2) on-line sensors for conductivity, turbidity, temperature
3) flow meters, weirs and level probe;
4) automatic sampler (sampling based on conductivity or flow rate)
5) electronic instrumentation, cellular phone connection.

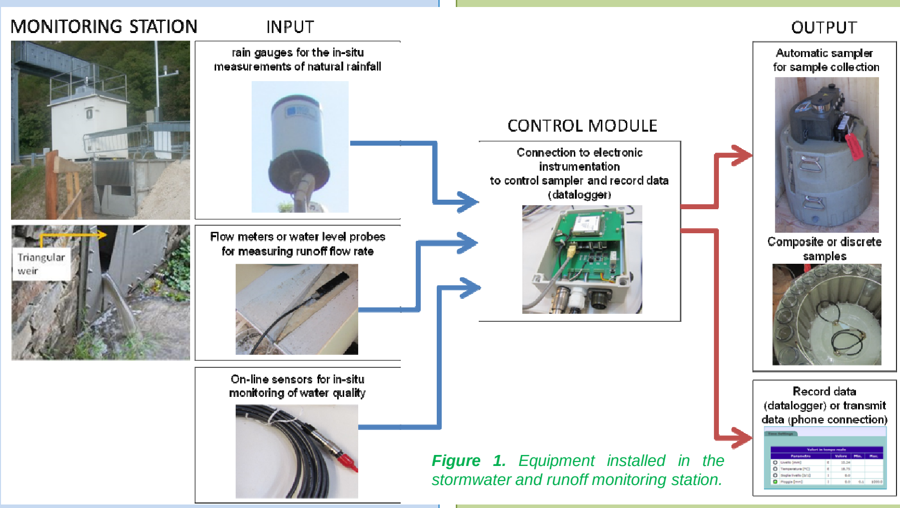

Figure 1. Equipment installed in the stormwater and runoff monitoring station.

Intra-storm sampling

Time-proportional sampling was performed for each event: intervals of 5-20 min for the first hour and 0.5-1-2 h thereafter.

Inter-storm sampling

27 events over a period of 3 years were monitored.

Event Mean Concentration (EMC) of pollutants

$$EMC = \frac{\sum_{i=1}^{N} C_i \cdot V_i}{\sum_{i=1}^{N} V_i}$$

Analytical parameters

TSS, electrical conductivity (EC), chloride, sulphate, sodium, cyanide, heavy metals (aluminium, zinc).

First flush

$$f_m = \frac{\sum_{i=1}^{j} M_i}{\sum_{i=1}^{N} M_i} = \frac{\sum_{i=1}^{j} C_i \cdot V_i}{\sum_{i=1}^{N} C_i \cdot V_i} \qquad f_v = \frac{\sum_{i=1}^{j} V_i}{\sum_{i=1}^{N} V_i}$$

RESULTS

The time of rainfall peaks coincides with the time of the peaks of flow rate (Figure 2A) due to the small area of the road (532 m^2). Conductivity is very high at the beginning of the runoff (> 2000 microS/cm for several hours), decreasing progressively during the runoff event.

Runoff water was completely absent during snowfall (Figure 2B), beginning only during the melting of snow caused by an increase in temperatures. The water runoff originated from snowmelting causes particularly high values of conductivity (around 5000 microS/cm) due to the low flowrate observed during snowmelt.

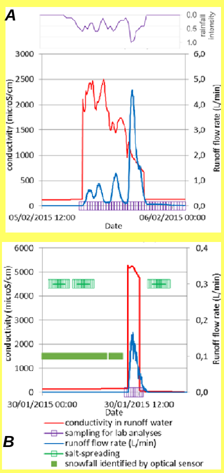

Figure 2. Monitoring of 2 events: rainfall intensity and snowfall, runoff flow rate, conductivity and salt spreading.

In some cases, chloride in runoff waters exceeds the standards for freshwater aquatic ecosystems (USEPA): 230 mg/L (chronic toxicity) or 860 mg/L (acute toxicity).

When the runoff is not enough for the complete washing of the road surface, a certain amount of salts remains on the road, subjected to resuspension in air during dry-weather periods.

The occurrence of "first flush" was observed for TSS, chloride, zinc (Figure 3), indicating that a large fraction of these pollutants is contained in the initial runoff and the peak of concentration precedes the flow peak.

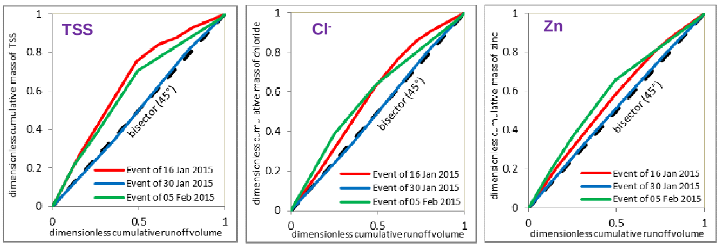

Figure 3. Assessment of "first flush" for TSS, Cl^-, Zn. First flush occurs when the curve is above the bisector

Events	TSS (mg/L)	EC (µS/cm)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	CN^- (µg/L)	Na^+ (mg/L)	Al (mg/L)	Zn (mg/L)
24-26 December 2013	14	175	42	2.5	2.2	28	-	-
04-06 January 2014	9	324	93	1.4	3.5	61	0.31	0.57
14-18 January 2014	42	425	125	1.5	14	80	1.18	0.88
07-09 February 2014	14	1314	321	3.1	5.3	256	0.43	2.23
13 February 2014	45	1159	353	2.3	12	226	1.37	1.27
16 January 2015	63	1392	398	13.3	14	252	1.47	1.59
30 January 2015	66	4703	1450	13.6	30	926	1.84	1.95
05 February 2015	47	1208	350	6.7	12	213	1.03	1.08
14 February 2015	33	1172	369	7.7	11	252	1.03	1.30
AVERAGE VALUES	***40***	***1319***	***389***	***5.8***	***11.6***	***255***	***1.1***	***1.4***
Last year, after optimization of spreading of de-icing salts								
9-12 January 2016	51	664	197	4.2	10	128	1.07	0.96
03 February 2016	129	1483	464	12.0	6.6	264	5.0	2.00
07 February 2016	11	571	165	7.2	<4	65	0.12	0.79
14 February 2016	10	381	104	4.9	4.2	65	0.35	0.60
17 February 2016	57	930	271	7.5	11.4	180	0.76	0.91
28-29 February 2016	35	254	62	3.9	4.2	45	0.72	0.49
5-6 March 2016	9	321	96	2.8	4.6	63	0.40	0.38
AVERAGE VALUES	***43***	***658***	***194***	***6.1***	***6.8***	***116***	***1.2***	***0.9***

Table 1. Event Mean Concentrations (EMC) in runoff water during rainfall and snowfall events in three winter periods (2013-2016).

The average EMC of Cl^- was 194 mg/L in 2016, lower than 389 mg/L in 2014-15.

The average EMC of Na^+ was 116 mg/L in 2016 with respect to 255 mg/L in 2014-15.

For pollutant originated from the traffic, the average EMCs of the parameters TSS, Al and Zn did not shown any significant influence by the reduction of de-icing application, because associated only to the vehicle passages.

Discharged masses of Cl^-, Na^+ were lower during the winter 2016, after implementation of de-icing salts reduction, compared with the previous period 2014-15.

	No. events	Mass of Cl^- (g)	Mass of Na^+ (g)
Winter 2013/2014	11	1093	736
Winter 2014/2015	7	495	318
Winter 2015/2016 (after optimization of spreading of de-icing salts)	9	316	224

Table 2. Mass of chloride and sodium measured in water runoff.

CONCLUSION:

The water pollution originated from de-icing salts used on roads was monitored during three winter periods. The strategies for reducing the de-icing salts application on the road led effectively to a reduction in the mass loads of chloride and sodium discharged in the runoff water. This approach constitutes a basis for the reduction of chlorides in water runoff and thus the impact on soils and groundwaters.

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