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Theme: Stormwater, pollutants, heavy metals, SuDS

In situ mapping of pollutants in Sustainable Urban Drainage Systems, a new methodology approach and preliminary results from the Netherlands

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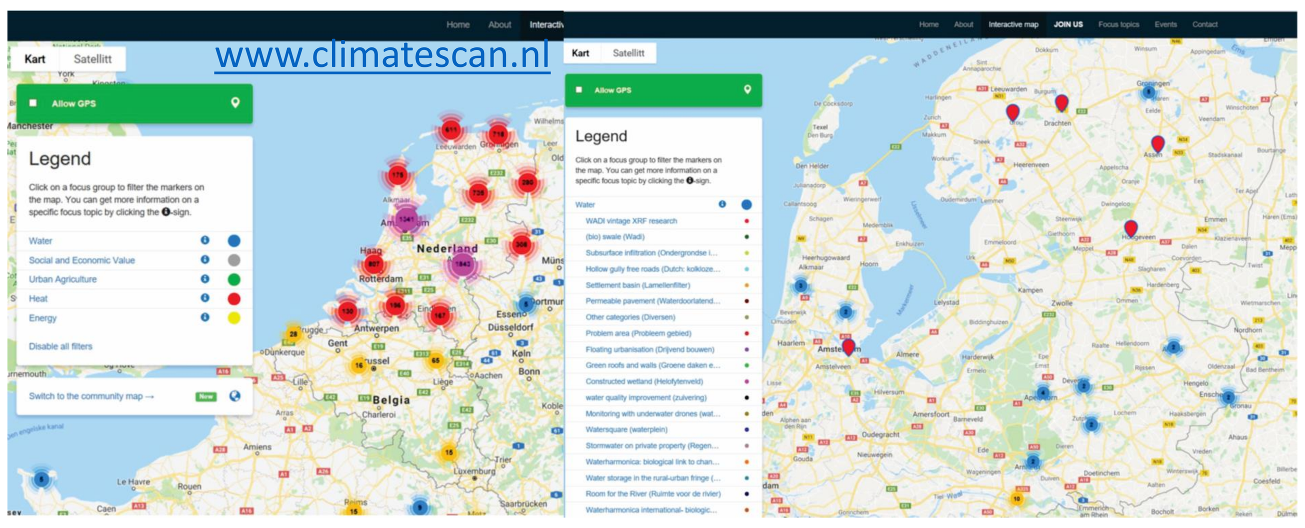
Stormwater runoff has severe negative and direct impact on the quality of surface waters and groundwater [1,2]. The impact can cause chemical and heavy-metal pollution. Applying well established methods to map pollutants in Sustainable Urban Drainage Systems (SuDS) is a step towards improving the water quality in the urban water cycle [3,4,5].
Traditional mapping of pollutants by the means of soil samples is costly and time consuming, which is the main reason why the environmental-technical functioning of rainwater facilities has not been systematically investigated on a large scale. X-ray fluorescence (XRF) is a known analysing method for finding metals and other components, for laboratory analysis and portable instruments [5,6]. A new approach of mapping method for pollutants in-situ is proposed, such as heavy metals in soil in SuDS, with case studies from The Netherlands where swales were implemented 20 years ago. In situ XRF measurements is a quick and cost-efficient analysis for heavy meatal mapping in the respect to contaminated soil [5,8].
In situ XRF measures of various elements, including heavy metals is carried out in a quick scan and accurate manner and measures both qualitatively and quantitatively [6]. It makes the time-consuming and costly interim analyses by laboratories superfluous. In this study, we suggest a new methodology approach for in situ mapping of pollutants in various swales that were implemented from 5 to 20 years ago. The results differ due to multiple factors (age, use of materials, storage volume, maintenance, run off quality, etc.).



Several locations reached unacceptable levels, above the national thresholds for pollutants. The spatial distribution of pollutants in the over 30 swales mapped in the Netherlands show that the preferred water flow in the SuDS controls the spreading of pollutants. The swales investigated are presented in an interactive way with the open source tool www.climatescan.nl, containing more than 250 swales, part of which has been investigated with in situ XRF measurements [5,8].

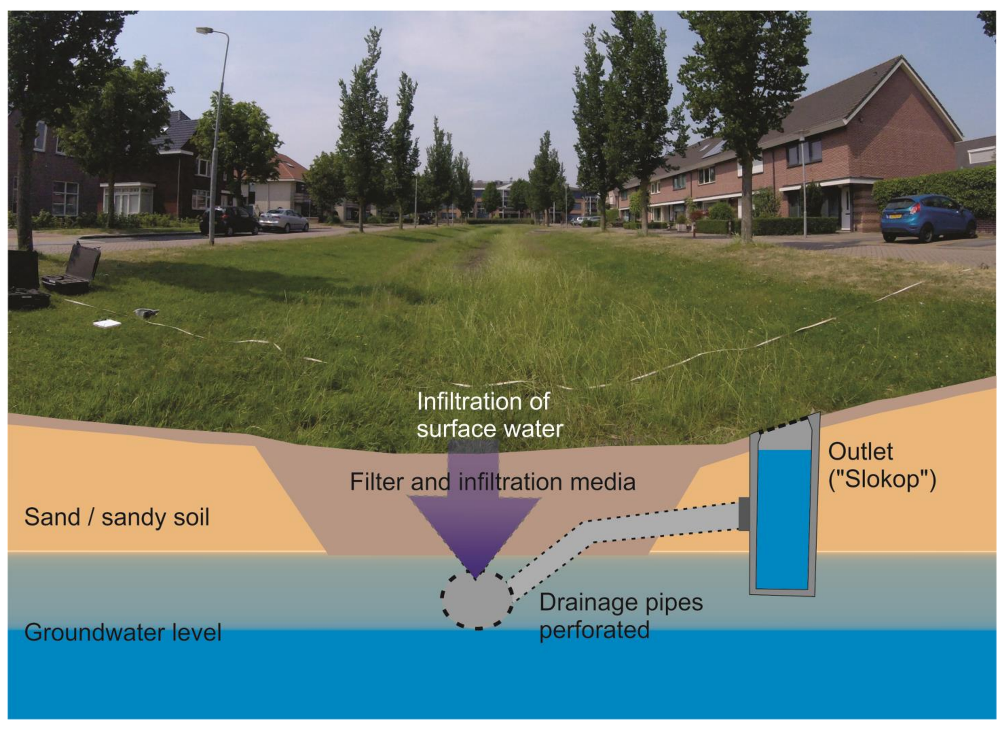


Figure: Principle sketch of a swale, location Limmen as background.

In Situ measurements with portable XRF

For a systematic data collection and a quick scan to cover the essential parts of a swale the proposed approach is profiling in cross-sections of the swale. Measuring points should be collected at a systematic interval, in this study 1 metre interval was executed. To cover the background values of the topsoil, measuring point on the outside or rim of the swale should be collected and crossing over to the other side. Such profiling will give background values and if any build-up of contamination, when profiling across the swale. It is important that the profiles cover the inlet and the deepest part of the swale, since water is the transporting media for the pollutants and the inlet and deepest part will contain water most frequent and for the longest period. The profiling approach should be repeated systematically to map the spread of the pollution in the swale.

Figure: Demonstration of in situ XRF measurements at every 1 metre along the profile across the swale. The vegetation is removed to measure on the topsoil, 0-3 cm, for measuring results to be comparable with lab results from soil samples. The instrument is pointed on the topsoil and each measurement is read for 60 seconds.

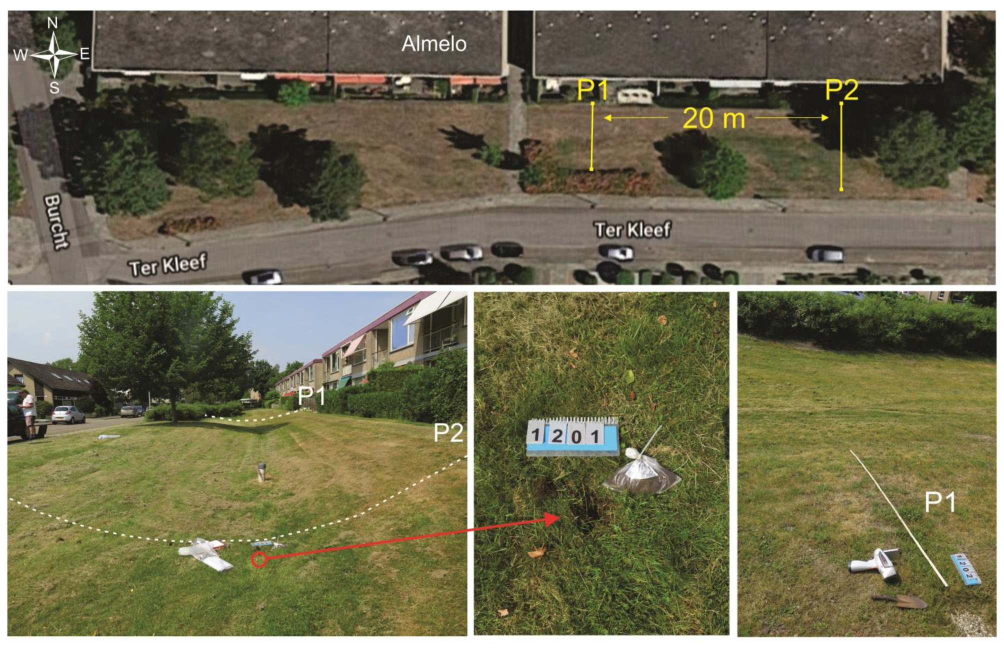


Figure: The swale at Almelo municipality, is approximately 40 metre-long and 10 metre wide. Two profiles with 20 metres between with measurements at each metre is collected with XRF instruments XL3#SN67136 at P1 and XRF instruments XL3t#SN36372c at P2. A soil sample for ICP-MS analysis was collected at mid-point of profile 2.

Results and discussion

This study shows that the highest concentrations are close to the inlet(s), based on the portable XRF measurements, which is coherent with other studies [9, 10, 11]. The variation of spatial distribution of pollutants in swales is confirmed in this study, with great variation over short distance (1 m). The distribution of the pollutants is controlled by the water ways in the swale, with highest measured values in the inlet and at deepest point of the swale, where water is most frequent and has the longest duration. These results confirm that stormwater is a significant contributor of pollutants to SuDS [4].

The research results are of great importance for all stakeholders in (inter)national cities that are involved in climate adaptation. SuDS is the most widely used method for storing stormwater and infiltrating in the Netherlands [4, 5, 8, 12, 13]. However, there is still little knowledge about the long-term functioning of the soil of these facilities.

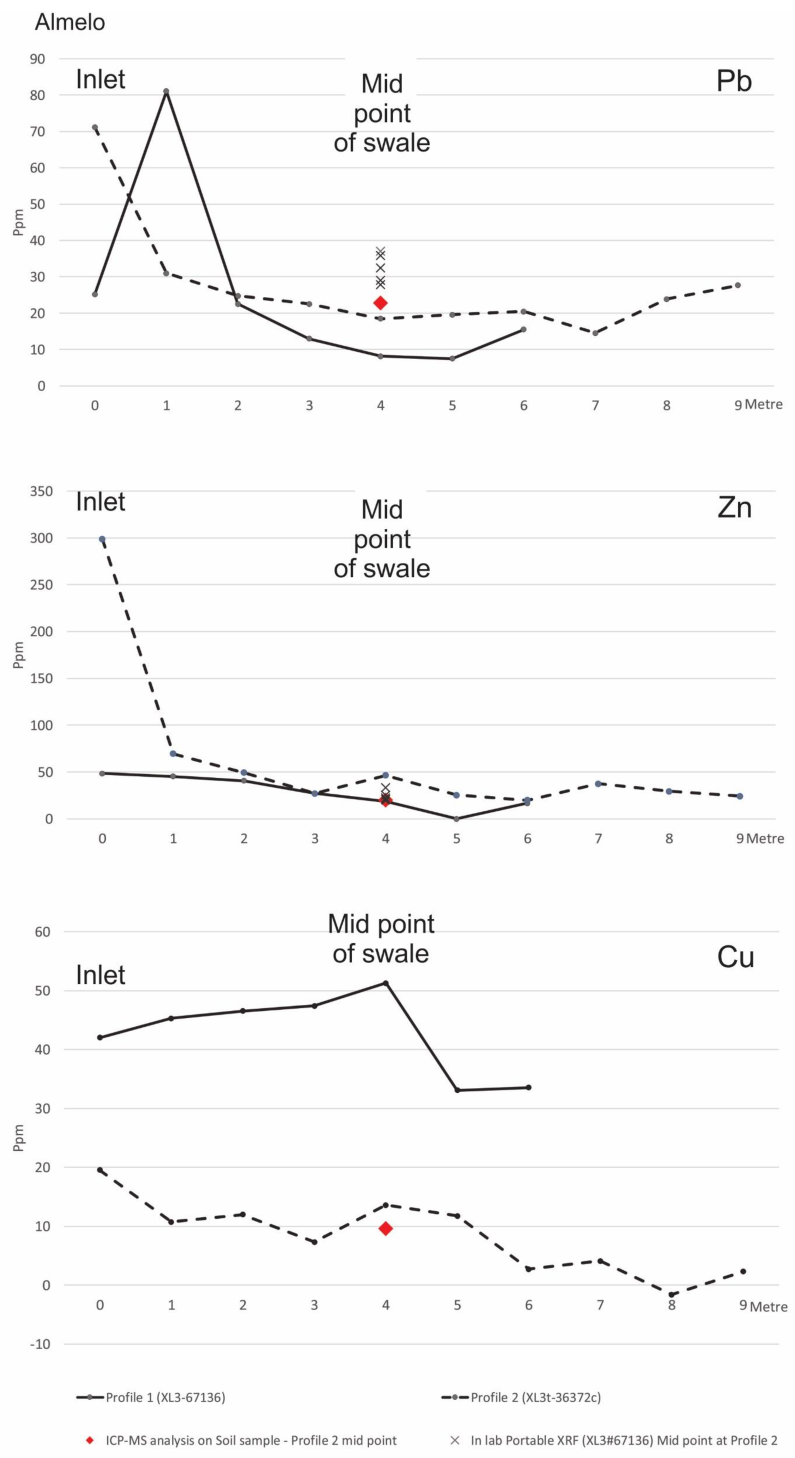


Figure to the right: Results from Almelo. Both profiles start at an inlet (0 m). Profile 1 is measured by XRF instrument #SN67136, and profile 2 by XRF instrument #SN36372c. There is approximately 20 metres between profile 1 and 2. A soil sample is collected at mid-point of profile 2. Elements in graphs from top to bottom: Pb – Lead, Zn -Zinc and Cu – copper.

Concluding remarks

The new portable XRF methodology approach presented for measurement of heavy metal pollutants in SuDS is a cost and time efficient method that give in situ results. The instrument has detection limits well below threshold values that makes this method valid for its purpose. With this quick-scan method the traditional soil samples and analyses by laboratories becomes superfluous. The results from the mapping of swales differ but there is a clear message; the water controls the distribution of pollutants in swales [9].

When in the field the profiling should be adjusted according to the design of the SuDS, making sure that the profiles cover the inlet, the deepest part as well the outer rim to represent the possible highest and lowest values of elements. The profiling should be executed systematically with a set interval. Control samples of soil should be collected and analysed in laboratory.

This quick scan XRF mapping methodology of topsoil will qualify to indicate if the topsoil is polluted or not according to the national or international standards [1, 13]. If pollutant values are found above threshold a follow up investigation is advised to mitigate before clean-up is proceeded [1, 4, 8, 13].

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