GLYPHOSATE RESIDUES IN GROUNDWATER IN SLOVAKIA

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Introduction

Glyphosate is a non-selective herbicide which is strongly sorbed to soil particles. It is widely used in agricultural, urban as well as forestry areas in Slovakia. Glyphosate targets a wide range of weeds and is used to protect corn, soybean and various kind of fruits and vegetables. In addition, glyphosate can be used for no-till and low-till farming to reduce soil erosion, and to facilitate integrated pest management as well as in non-agricultural settings such as forests, parks or public spaces. It is approved for use in railway lines and even for use in lakes and rivers.

Glyphosate has been already worldwide detected in soils, crop products, crop-fed animals, freshwater and organisms living in freshwater (Battaglin et al., 2014; Pérez et al., 2011) but also in groundwater, bottled drinking water or human urine (Rendón-von Osten et Dzul-Caamal, 2017).

Glyphosate shows low mobility or even immobility in soil and is unlike to leach into ground water. Despite its relatively low mobility in soil, groundwater contamination can occur due to several factors. First significant pathway for glyphosate to reach groundwater is through runoff and erosion. Glyphosate applied to fields can be carried away by spray drift, rainfall or irrigation water, leading to runoff into nearby surface water bodies, from where it can be infiltrated and to get into groundwater. Runoff is more likely to occur in areas with high rainfall or intense irrigation practices. Leaching occurs when glyphosate moves downward through the soil profile and reaches the saturated zone, where groundwater is present. In some cases, plant protection products containing glyphosate are directly applied in aquatic ecosystems what can lead to infiltration and percolation to groundwater (Battaglin et al., 2014).

Methods

Glyphosate is the herbicide with the biggest consumption in Slovakia. In 2021, 346 157 kg of the active substance glyphosate was used in Slovakia, what is nearly 20 % of total amount of all applied pesticides (Figure 1). The consumption has growing tendency, which was in 2021 more than doubled compared to year 2011 (Figure 2). In Slovakia, glyphosate is authorized for use in the most cultivated crops such us cereals, oilseed rape and corn, in various types of fruits and vegetables, in orchards, grasslands, woodlands, railways, in lands not intended to wear vegetation as well as in water reservoirs, waterways and irrigation canals. In total, 38 glyphosate based plant protection products are authorized in Slovakia.

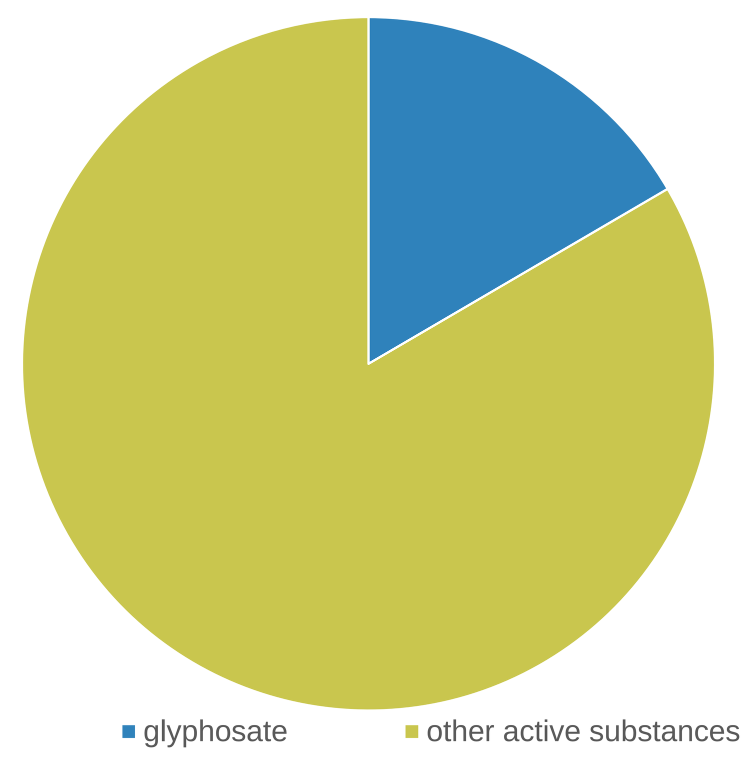

Figure 1: Consumption of glyphosate among all pesticides used in SR (2021)

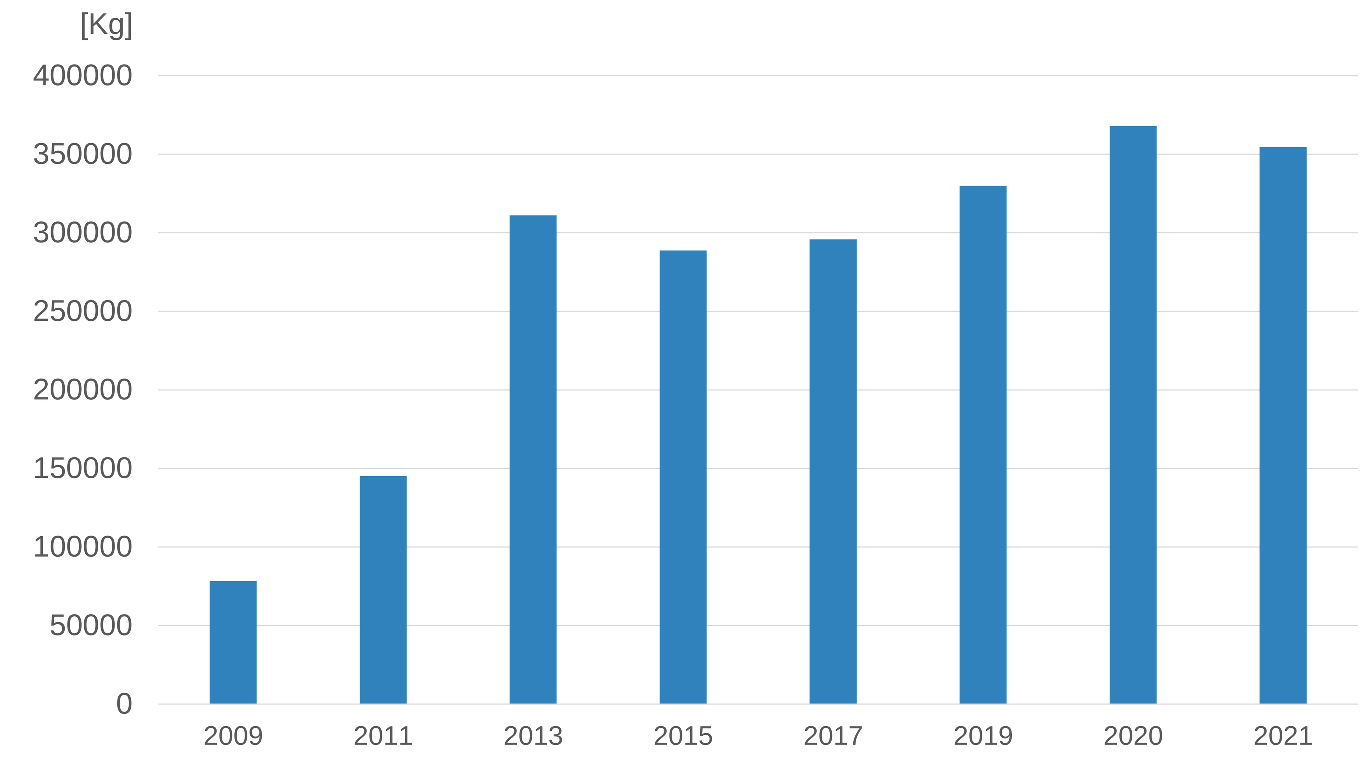

Figure 2: Total consumption of glyphosate in Slovakia per year [kg]

The authorization of plant protection product is conditioned by low concentrations resulting from modelling of predicted environmental concentrations in groundwater (PECgw) in models FOCUS for the scenarios relevant for Slovakia (Hamburg, Kremsmünster, Châteaudun and Piacenza). Concentration 0.1 µg/L is the parametric value for the individual pesticide allowed in water intended for human consumption (Directive (EU) 2020/2184). The concentration 0.05 µg/L is a limit concentration in Slovakia used during product evaluation, above which the restriction of use in the second protection zone of drinking water sources is applied.

There is the tiered approach used in the groundwater risk assessment. The modelling of the predicted environmental concentrations is the first tier and since this tier shows the results which comply with the requirements and meet the limit values, there is no need for performing higher tiers of risk assessment. The first tier represents the worst case scenario. It is more conservative compared to higher tiers such us leaching studies, lysimeter studies or monitoring, which stand for more realistic assessment of the leaching behaviour of the active substance (SANCO/13144/2010). Because of these reasons, the risk evaluation process of pesticides containing glyphosate is readily done and authorization can be granted.

The targeted monitoring of glyphosate in groundwater was conducted in Slovakia in 2020 and 2021, with 80 monitoring objects in 2020 and 102 objects in 2021. The monitoring was realized by Water Research Institute due to high risk associated with glyphosate in surface waters, since many underground sources of drinking water are in areas where high interaction between surface and groundwater occurs.

Results and discussion

The evaluation of predicted environmental concentration of glyphosate in groundwater for each of 38 evaluated products resulted in concentrations <0.001 µg/L for all scenarios relevant for Slovakia. All 38 products containing active substance glyphosate were approved for use and authorized with no additional restriction of use regarding protection of groundwater.

During the monitoring in 2020 and 2021, the limit concentration 0.1 µg/L was exceeded in 9.9 % of measured samples. The maximum of 8.5 µg/L was reached in one measured sample, while other exceedances of the limit ranged between 0.1 – 0.33 µg/L. In 21.5 % of samples the national limit 0.05 µg/L (limit for exclusion of use from the protection zone of water resources) was exceeded. It must be mentioned that the detection limit for glyphosate was 0.075 µg/L, so number of samples with concentrations of glyphosate over 0.05 µg/L may be higher.

Table 1: The predicted concentrations and concentrations of glyphosate found in monitoring in Slovakia during years 2020 and 2021

concentration	PECgw modelling	Monitoring
< 0.001 µg/L	100 %	-
< 0.075 µg/L	-	78.5 %
0.075 – 0.099 µg/L	0 %	11.6 %
≥ 0.1 µg/L	0 %	9.9 %

According to EFSA conclusion on glyphosate, further information is needed to assess the contamination route through run off, especially in situations where application to hard surfaces as well as subsequent surface water contamination and bank infiltration to groundwater may occur. Glyphosate and its metabolite AMPA have specific ionic characteristics due to which, leaching mechanisms and routes simulated by FOCUS GW models may not be the most relevant to assess the potential of leaching to groundwater.

The problem is wide and enormous consumption of this herbicide and not fully reliable prediction of its concentrations in groundwater. Prediction of the glyphosate leaching to groundwater for individual products does not reflect the reality, when big amount of the products containing this substance is applied. The contamination caused by one product may not be significant or can be even negligible, but sum of all uses may become problematic.

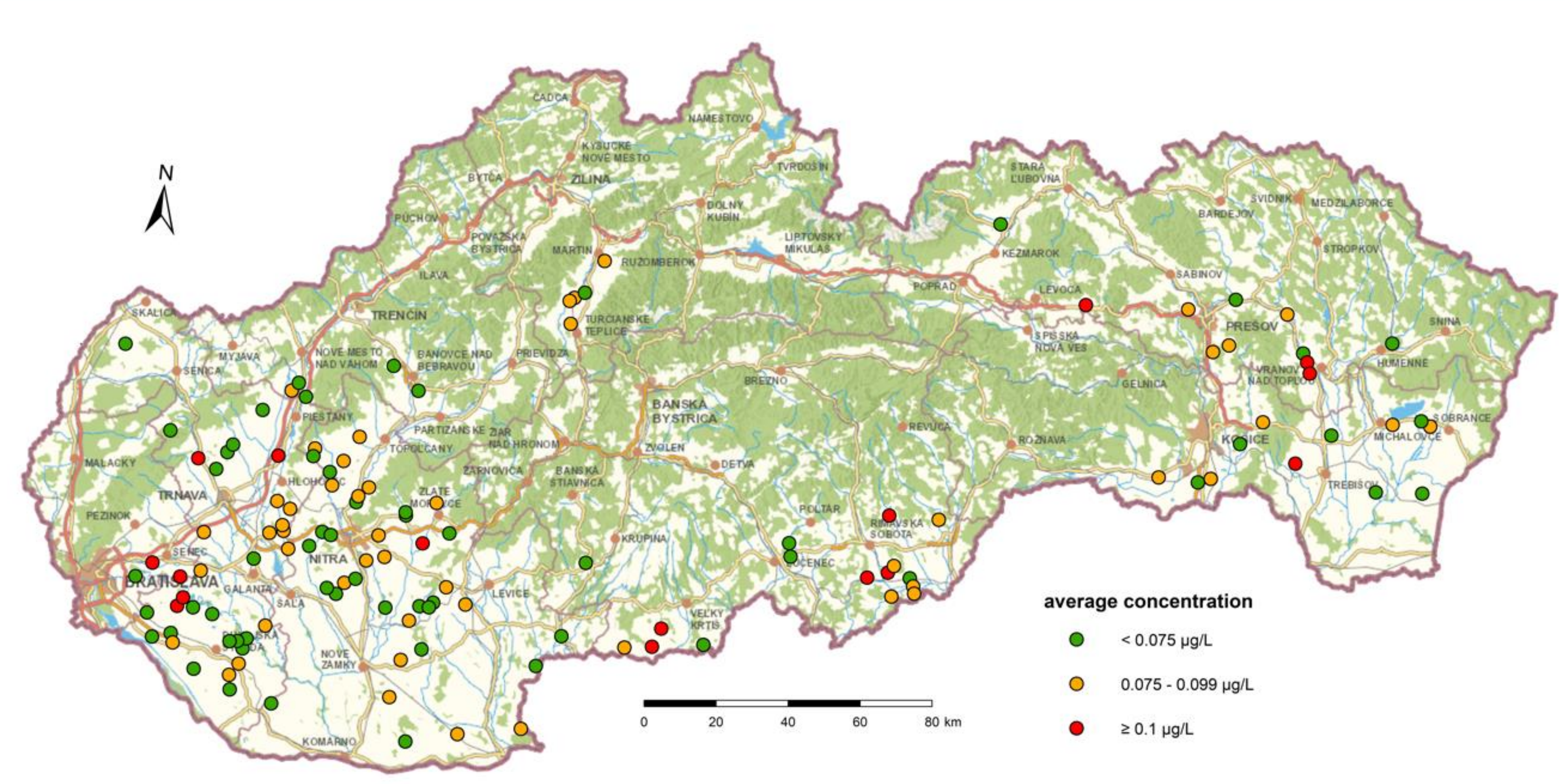

Figure 3: The map of average concentrations of glyphosate measured during monitoring in SR (2020 - 2021)

Conclusion

Contamination of groundwater by glyphosate is a growing concern due to its widespread use, its ubiquity as well as potential health effects. Monitoring in Slovakia has shown the presence of glyphosate in various samples of groundwater. Although glyphosate may not exhibit high mobility in soil, the combination of runoff, leaching, accumulation and contaminant transport can lead to groundwater contamination. Understanding these pathways is important for effective management strategies and the protection of groundwater resources. It is very important for regulatory agencies to continue monitoring and regulating glyphosate use to minimize the contamination. Glyphosate and its metabolite AMPA were selected among monitored indicators in groundwater in the Slovak State Hydrological Network for the following years, according to Framework program for water monitoring in Slovakia for the period of 2022-2027. There is also need for further research for better understanding of risks associated with huge consumption of glyphosate-based products and its occurrence in groundwater as well as need to develop effective mitigation strategies. Key role is also use of prediction models which are taking into account bank infiltration from surface waters.

References

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