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IDENTIFICATION OF STUDY SITES FOR PLACEMENT OF SEDIMENT TRAPS IN VEGETATED BUFFER STRIPS

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The aim of this contribution was to outline the decision procedure for selecting potential sites suitable for installing sediment traps in vegetation buffer strips in the Fugnitz catchment, Austria. The selection procedure consisted of GIS data processing where the contributing areas of specific sites were specified according to the selected criteria (i.e. slope above 2°, vegetation strip in between agriculturally used land and river network, contributing area of at least 300 m^2). Available landuse maps were updated with formerly not-digitized structures potentially influencing connectivity (e.g. ephemeral streams and road ditches) which were mapped in the field. From 31 pre-defined sites 15 were selected, taking into account as additional selection criteria the slope angle, soil erodibility and size of the contributing area. Two sites were selected for further investigations – i.e. installation of the sediment traps in vegetation filter strips collecting event-based sediment yields from adjacent arable fields. We conclude that GIS analysis has shown to be useful for the first step-delineation of potential sites of interest on the catchment scale. However, field-based surveys have been shown to be inevitable to obtain on-site information on vegetation characteristics and fine-scale topographic and management information.

Keywords: water erosion, sediment delivery, connectivity, buffer strips

The process of water erosion not only causes soil loss and changes in soil properties on-site, but is followed by various off-site effects (Antal et al., 2014). According to Boardman et al. (2019), off-site impacts of the soil erosion are often of greater social and economic concern in Western Europe than on-site impacts. They fall into two related categories: muddy flooding of properties and ecological impacts on watercourses because of excessive sedimentation and associated pollutants. Scientists have tried to understand, describe and quantify surface runoff and sediment fluxes at multiple scales for many years. In the past two decades, a new concept called connectivity has been used by Earth Scientists as a means to describe and quantify the influences on the fluxes of water and sediment on different scales: aggregate, pedon, location on the slope, slope, watershed, and basin (Keesstra et al., 2018). When considering the hydro-geomorphic processes in catchment systems, according to the connectivity approach, three types of linkages can be differentiated (Fryirs et al., 2007):

a) Longitudinal (upstream – downstream and tributary-main stem relationships), which drive the transfer of flow and sediment through the catchment.
b) Lateral (channel – floodplain and slope-channel relationships), which manage the supply of materials to the channels.
c) Vertical (surface-subsurface) interactions of water, sediment and nutrients.

Although several authors have pointed out that the spatial distribution of vegetation along slopes has a significant impact on the reduction of surface runoff and sediment entrainment under various environmental conditions (Li et al., 2009, Pugh, 2014), relatively little information is available on the effect of spatial and species composition of vegetation buffer strips on lateral connectivity, especially when considering long-term monitoring (Yuan et al., 2009; Keesstra et al., 2012; Poeppl et al., 2012).

Various techniques are used worldwide to assess the instant or long-term intensity of water erosion processes in the field, such as surface runoff trapping, volumetric analyses of erosion and rainfall simulations (e.g. Antal et al., 2014; Toy, Foster and Renard, 2012). Mainly because of time, labour and cost requirements, laboratory and field experiments on hillslope scale predominate over comprehensive studies of the causes and effects of water erosion on the catchment scale (Maetens et al., 2012). On the one hand, field measurements are very important as they provide information for model calibration. On the other hand, GIS-based assessment of erosion risk allows capturing the spatial variability of erosion factors on the catchment scale (Mitasova et al., 2013; Šinka and Kaletová, 2013). Due to hydro-geomorphic complexity inherent in catchment systems (Bracken et al., 2015; Poeppl, Keesstra and Maroulis, 2017), upscaling of plot-scale observations often does not result in accurate watershed-scale estimates of runoff and erosion (Sadeghi et al., 2013).

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Considering the special geomorphologic situation of Austria, of which more than 60% is the Alpine territory with high relief energies, erosion and erosion control have been a major issue for a long time. Land management is certainly one of the key factors for on-site erosion risk. With the participation of Austria in the European Union, the first concerted efforts to reduce the soil erosion by water at the national scale were initiated by the Austrian Programme for a Sustainable Agriculture that was launched in 1995 (Strauss and Klaghofer, 2006). It offered environmental contracts to farmers who were willing to implement specific protection measures, such as erosion control on vineyards, orchards and farmland. Besides the given subsidy, some farmers found it difficult to follow these incentives due to various reasons, such as inadequate machinery, additional planning, work and organization.

The loess soils of the Federal State of Lower Austria are especially prone to the soil erosion by water. The situation becomes even more problematic when protected areas are affected by high input rates of (nutrient- and pollutant-laden) sediment input, as in the case of the Thayatal National Park.

The aim of this contribution is to outline the decision procedure for selecting potential sites suitable for the assessment of sediment trap efficiencies of vegetation buffer strips in the Fugnitz River catchment.

Material and methods

Study area

The Fugnitz River catchment (size ~138 km^2) is located in Lower Austria near the Czech Republic border (Figure 1). About 34% of the catchment area is covered by forests, 5% is taken by built up area, while 60% is agricultural land. After high precipitation events, the Fugnitz River is very often carrying (nutrient- and pollutant-laden) sediments, mainly originating from extensively used agricultural areas, further entering the Thaya River in the Thayatal National Park (Figure 2).

Selection of study sites using GIS

Since our aim was to study the sediment trap efficiency of vegetation filter strips, the selection of study sites was limited to strips of vegetation located adjacent to intensively cultivated agricultural land. Potential study sites were pre-selected via visual interpretation of recent orthophotos (source: the Federal State of Lower Austria). Thereafter, for each of the selected vegetation strips contributing areas with a minimum size of 300 m^2 were calculated in ArcGIS v. 10.2 using a DEM with a resolution of 1 m by 1 m (source: the Federal State of Lower Austria). This area threshold was chosen to avoid locations with very small contributing area where no surface runoff was observed in the field. Therein, we adopted the approach by Fryirs et al. (Fryirs et al., 2007; Poeppl et al., 2012), i.e. taking into account only areas with slope angles above 2°, reflecting energy conditions capable of entraining and transporting sediment along hillslopes. 15 were selected from 31 pre-defined sites, taking into account slope angle, soil erodibility expressed as K-factor according to Strauss (2007) and size of the contributing area as additional selection criteria.

Figure 1 Location of the Fugnitz River catchment in Austria
Source: Poeppl et al., 2013

Figure 2 Visual difference in water quality at the confluence of the Fugnitz and Thaya Rivers caused by high sediment loads in the Fugnitz River
Photo: Aydin, 2017

Field survey

The conditions of 15 sites were investigated in the field during the field campaign in summer 2017. Crucial information on vegetation buffer strips and adjacent arable fields, such as crop type, vegetation buffer structure, observed water erosion processes, accessibility and features not shown on land use map or ortophotos were recorded in the field. After the field visit, the original land use map of the pre-selected sites was updated with formerly non-digitized structures potentially influencing connectivity (e.g. ephemeral streams and road ditches) (Figure 3).

Results and discussion

According to the landuse analysis, the vegetation strips in the Fugnitz catchment were generally located along waterways. About 32% of the vegetation strips have been dominated by grasses and herbs, occasionally accompanied by scattered trees or shrubs. They were selected as priority areas because of their common proximity to agricultural land (Figure 4). The example showing the selected vegetation strip including calculated contributing areas is shown in Figure 3.

Two sites (i.e. "Felling" and "Heufurth"), meeting our selection criteria as described above, were selected for further investigations – i.e. installation of sediment traps in vegetation filter strips collecting event-based sediment yields from adjacent arable fields. A 2.5 m belt of predominantly grassy vegetation with minor seasonal occurrence of various herbaceous species has been located on a small slope between arable land and a functional road ditch draining the surface runoff to the river network at the "Felling" site (Figure 5a). The arable field has been linked to a 2.5 m belt of grasses and herbs (especially *Urtica dioica* L.) forming a first line of riparian vegetation at the "Heufurth" site (Figure 5b). To further assess the sediment trap efficiency of vegetated filter strips, constructed sediment traps (60 × 40 × 30 cm) were placed and secured with 10 cm long nails 2 m from the upper border of the strip. Moreover, the sites have been equipped with rain gauges and soil moisture measurement devices.

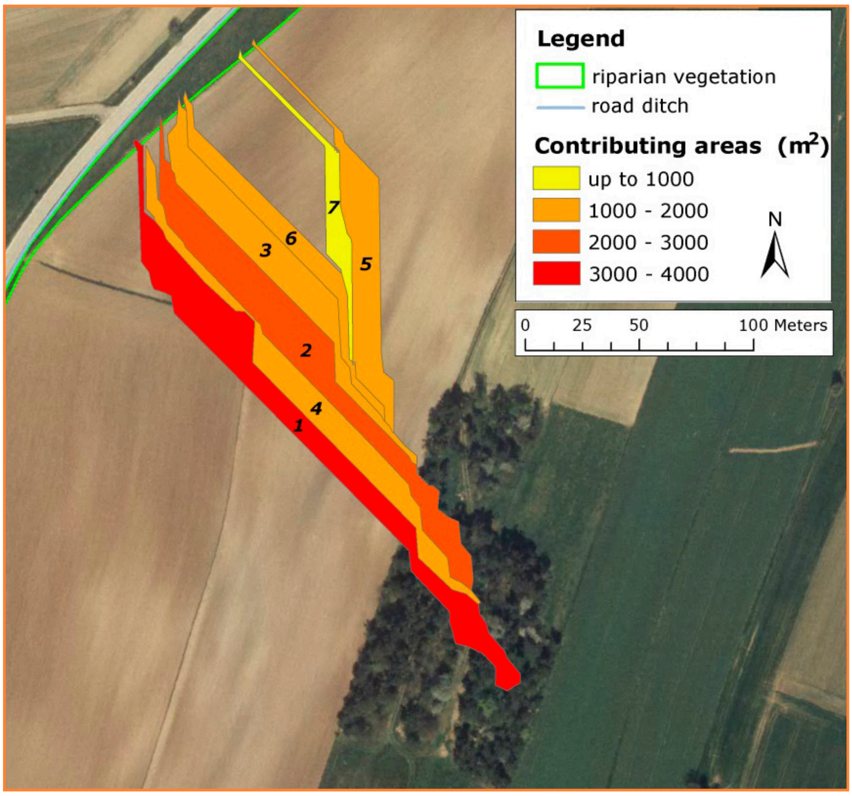

Figure 3 The selected vegetation strip including calculated contributing areas along a road ditch
Source of the ortophoto: The Federal State of Lower Austria, 2017

Figure 4 Exceeding of sediment trap capacity of local grass filter strip after rainfall event
Photo: Aydin, 2017

Conclusion

In our contribution, we have tried to outline the procedure of the selection of suitable study sites for further investigations on the effects of vegetation strips on lateral sediment connectivity. GIS analysis has shown to be useful for the first step-delineation of potential sites of interest on the catchment scale. However, field-based mapping has been shown to be inevitable to obtain on-site information on vegetation characteristics, fine-scale topographic and management information.

Figure 5 Experimental setting for event-based sediment yield and vegetation buffering efficiency measurements, strip in a) "Felling" and b) "Heufurth"
Photo: Aydin, 2017

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