



Transforming **U**nsustainable
management of soils in key
agricultural systems in EU and China

Developing an **i**ntegrated platform of
alternatives to reverse soil degradation

Nutrient loss by water movement, runoff and leaching



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Short description

Nutrient loss through water movement, runoff, and leaching is a significant concern in agriculture and environmental management. Runoff occurs when excess water flows over the surface of the soil instead of being absorbed, while leaching is the process by which water percolates through the soil, dissolving and transporting nutrients down in the soil profile. The movement of dissolved soil nutrients, especially nitrate, toward surface water and groundwater can lead to water contamination if not managed properly. The nutrients, which are poorly soluble in water (e.g. phosphorous), are moved with the surface movement of solid soil particles washed away by runoff water.

Target area

Water movement in soils is mainly determined by local meteorological factors (in particular rainfall and its temporal distribution) and soil properties, nutrient loss can arise in almost all cropping systems. Net downward water movement occurs when precipitation exceeds evapotranspiration (i.e. the amount of water transferred from the soil surface to the atmosphere through surface evaporation and transpiration by plants). Seasonal patterns of precipitation and irrigation are important for



pesticide and fertilizer runoff and leaching because they determine when downward water flow occurs in the soil during the year.

Problem identification

The problem of nutrient loss due to different kinds of water movement can be identified partly by field observations related to water erosion (runoff) and partly by soil sampling requiring a few meters of drilling (leaching). Surface erosion assessment is supported by

the TUDI app, under “soil erosion” measures, while proper nutrient management planning can support to prevent leaching, available under the “fertilizer” tool (dev-tudi.web.app).

Detailed description of protection and restoration strategy

One of the common targets of Best Management Practices (BMPs) is minimizing the fertilizer movement by leaching and

runoff on agricultural fields.

Tillage practices have a major impact on

soil structure, with the absence or reduction of tillage favoring the formation of larger and more persistent soil aggregates and associated macroporosity. Soil structure affects the amount of water stored in the soil and the flow of water through the soil, which can be significantly accelerated by the presence of cracks (especially larger cracks between aggregates, macropores) and biopores (such as earthworm burrows and old root channels). Infiltration of water through macropores into the soil is increased, reducing the potential for surface runoff, but also increasing the rapid downward movement of water through the soil profile. Under intensive tillage, macropores become blocked and infiltration capacity is generally reduced. As a compromise, shallow tillage can be used to break up macropores close to the soil surface, preventing some of the rapid downward movement, thus allowing fertilizers (and e.g. pesticides) to pass more evenly through this surface layer.

Organic matter content of the soil (not referring here the peat soils or organic soils with above 20% organic matter content) also influences soil water retention, mainly through water binding to organic matter particles and higher soil pore volume due to more strongly developed soil aggregates.

In general, water flow through soil, particularly as affected by soil conditions, is strongly influenced by soil management practices. Cover crops influence soil organic matter content, microbial activity and water balance. In addition, tillage practices not only affect macropores but organic matter



Fig. 1: Drilled, undisturbed soil sampling to identify the nitrate profile under an arable parcel.

levels in topsoil and microbial activity levels also. No- or reduced tillage is known to increase organic matter content and microbial activity in the upper topsoil layer.



Pros/Cons of technique, obstacles to implementation

Measures	Application
Spatial and timing adaptation of applications	Restrict applications on vulnerable fields. Avoid application shortly before or during the groundwater recharge period. Consider alternative products
Optimise crop rotation	Select crop rotation (alternate winter and spring crops, consider plants with tap- and fibrous-root systems)
Adapt tillage practices	Consider using at least shallow tillage to disconnect soil macropores in vulnerable fields
Grow cover crops	Select cover crops to fit with the rotation of main crops
Optimise irrigation practices	Calculate the correct irrigation volume (balance)

A lot of information relevant to understanding the water movement in the soil and catchment is usually available. Some can be received from land management authorities; some files may be directly available from the farmer. Sometimes, information is no longer available (e.g. due to a short-term land lease, a change

in ownership, or lost maps). Therefore, a thorough field audit during times of drain flow should be done to verify if there is drainage and if it is fully operational. Ideally, the drainflow should be monitored in relation to time of rain, intensity and time/amount of drainage outflow.



Effects/results/case studies

Given the differences in soil structure, soil texture and organic matter content, it is unsurprising that downward water flow within and between soil profiles is highly variable. The average depth to which water moves down the soil profile after rainfall (or improper irrigation) is primarily a function of soil texture and distribution of pores in different sizes. Soil pore sizes can vary over a wide range - water in larger pores can move much faster and further than what we might assume to be the 'average' distance at a given location, so there is a large spatial variability in water flow, even within a single soil profile.

Artificial drainage involves the installation of pipes or ditches, but in drought-prone



Fig. 2: Sampling of shallow subsurface water for nitrate monitoring.

areas it should be used carefully (considering land-use change in areas that are frequently covered by water), as it can dry out the area more than necessary in the long term.

More literature

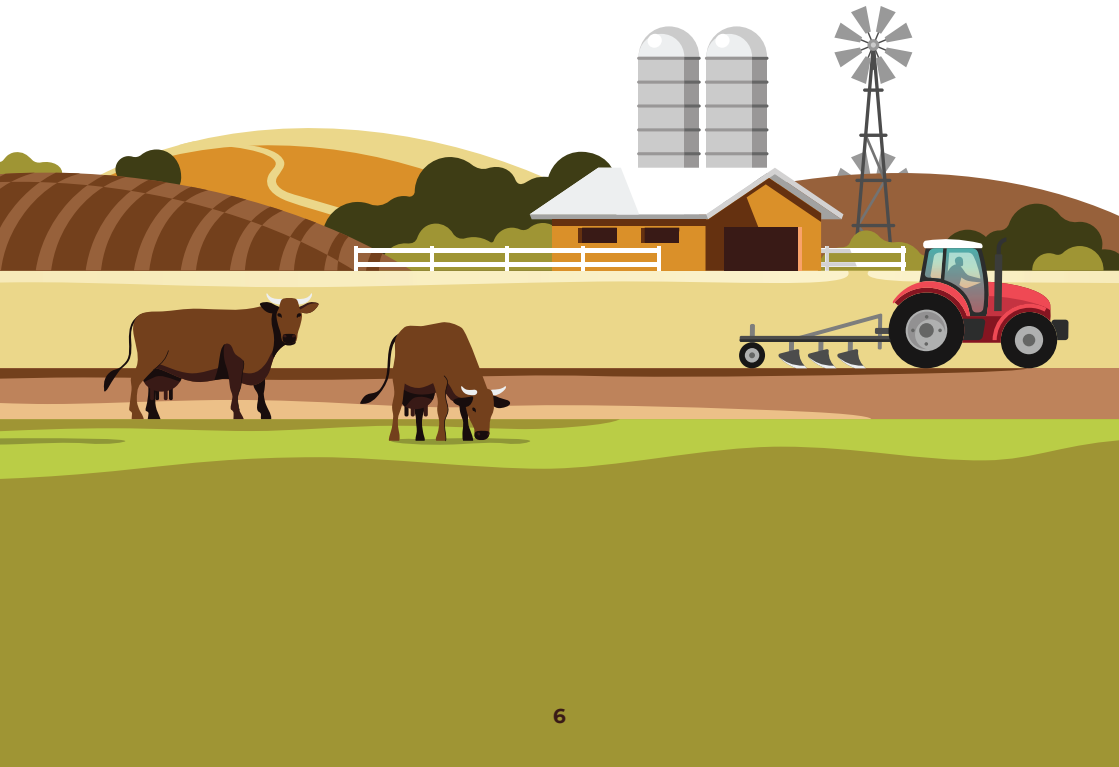
www.TOPPS-life.org

Summary

Soil texture, organic matter, rainfall, and land management practices can all affect the surface and subsurface water movements on a particular land. As a result of water movement, the dissolved soil nutrients or contaminants can be washed away from the soil surface into the subsurface layers or nearby water bodies due to factors like heavy rainfall or improper irrigation.

With proper fertilization practices, the risk of nitrate leaching can be reduced,

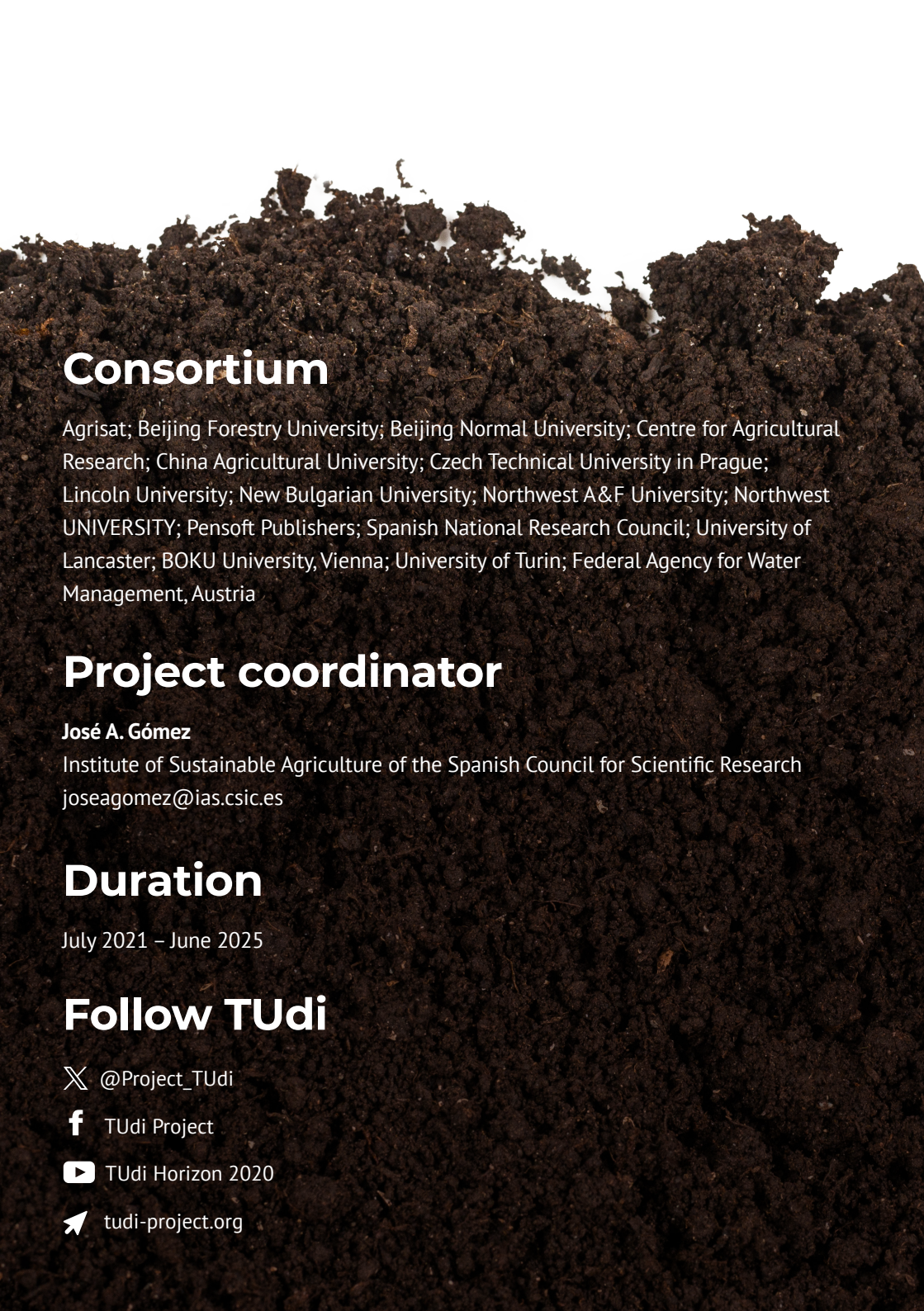
so that nitrate accumulation can be kept at a depth where the plant root system can take it up in the next growing season so that nitrate is not present or is present in minimal amounts in the deepest layers and does not become a threat to groundwater. Planting cover crops can help prevent the leaching of nutrients by stabilizing the soil surface and improving organic matter content while establishing vegetated areas (buffer strips) near water bodies can reduce nutrient runoff and enhance water quality.



Summary table

	Rating	Comments
Soil health overall	**	
Water budget	**	
Soil structure	*	
Erosivity	*	
Nutrient balance	***	
Soil life	**	
Practicability	-	
Economy	-	





Consortium

Agrisat; Beijing Forestry University; Beijing Normal University; Centre for Agricultural Research; China Agricultural University; Czech Technical University in Prague; Lincoln University; New Bulgarian University; Northwest A&F University; Northwest UNIVERSITY; Pensoft Publishers; Spanish National Research Council; University of Lancaster; BOKU University, Vienna; University of Turin; Federal Agency for Water Management, Austria

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