

EU4GREEN

WP 1-6: CODES OF GOOD
AGRICULTURAL PRACTICE –
KEY ELEMENTS TOWARDS
NITROGEN USE EFFICIENCY

September 2025



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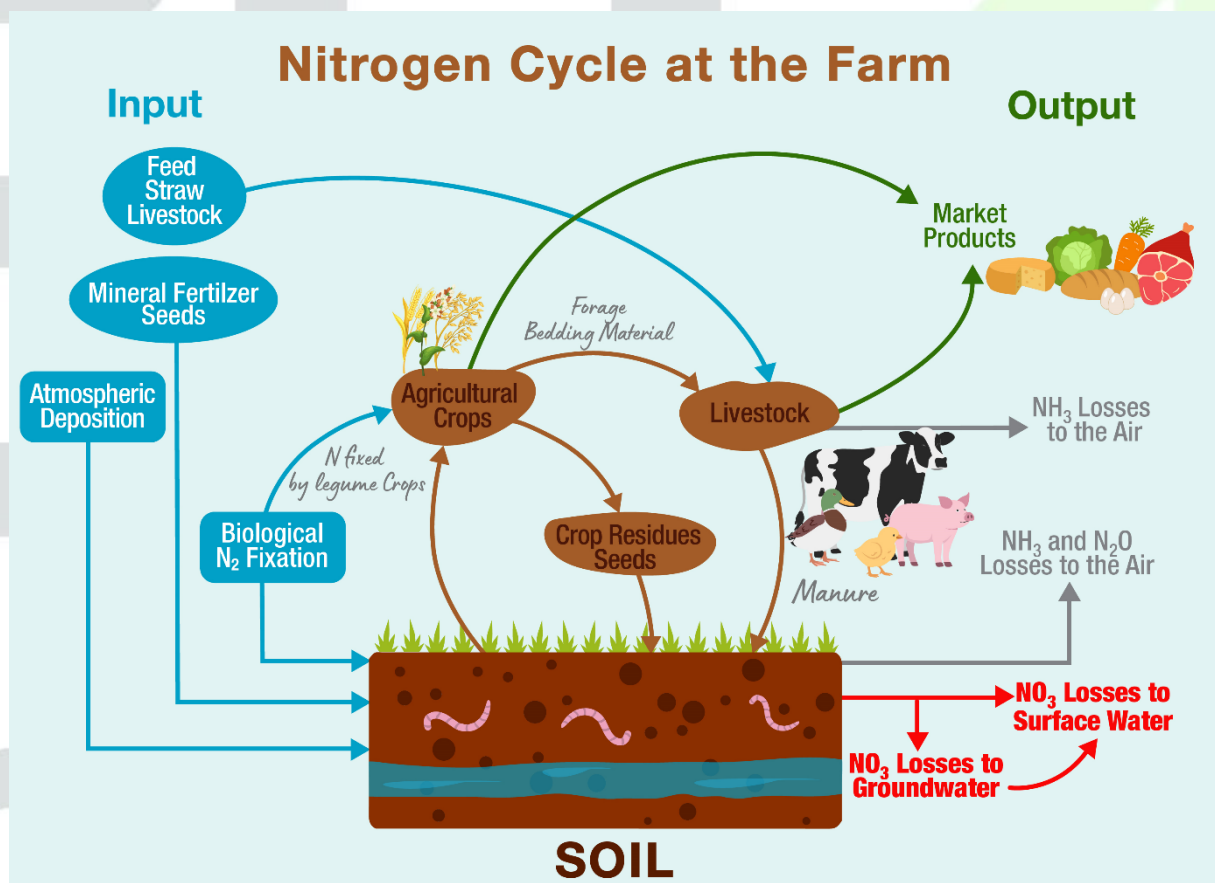
1. OBJECTIVES AND HOW TO USE THIS BROCHURE

1.1 Nitrogen management required by the EU Nitrates Directive (91/676/EEC)

The Nitrates Directive aims to protect water quality across Europe by preventing nitrates from agricultural sources from polluting ground and surface waters and by promoting the use of codes of good agricultural practices to manage nitrogen use efficiently.

The Directive aims to reduce water pollution from nitrates used in agriculture by

- monitoring nitrate concentrations of water bodies,
- designating nitrate vulnerable zones and
- establishing codes of good agricultural practices and measures to prevent and reduce water pollution from nitrates.



Reducing nutrient losses to ground and surface water means more nutrients are available to the farmers, reducing the need for expensive mineral fertilizer inputs. The aim is to increase nitrogen efficiency at farm level and to close the farm nitrogen cycle as far as possible.

Nitrogen is essential for agricultural crop production and can be applied in the form of commercially produced mineral fertilizers, as well as through organic fertilizers such as animal manure, compost or sewage sludge. Another important source of nitrogen in agro-ecosystems

is biological nitrogen fixation by leguminous crops, such as alfalfa, clover, clover-grass-mixtures, soy, peas and field beans.

However, when used excessively or under poor conditions nitrogen can be a major source of water and air pollution, with negative impacts on both biodiversity and the climate.

Water pollution means nitrates losses to ground- and surface water. Nitrates can be leached from the soil into groundwater. Surface water run-off and soil erosion can lead to nitrate losses to surface water. Air pollution is caused by gaseous nitrogen losses in the form of ammonia, mainly from manure and mineral fertilizers – especially urea - and to a lesser extent from the soil. In addition, gaseous nitrogen losses from the soil can occur as climate-relevant nitrous oxide, mainly after fertilization in wet and compacted soils with anaerobic conditions (incomplete denitrification).

1.2 Definitions

Liquid manure refers to the liquid component of livestock excrement (urine) when collected separately from the solid components.

Solid manure refers to the solid component of livestock excrement (manure). This is often mixed with materials used as bedding for animals in the barn, such as straw.

Slurry refers to a mixture of solid and liquid components of livestock excrements (total urine + manure). Sometimes this mixture is diluted with water so that it can be spread more evenly on the field as fertilizer.

1.3 How this brochure can help...

The aim of this brochure is to support farmers in North Macedonia in increasing their nitrogen efficiency by closing nitrogen cycles on the farm and preventing nitrogen losses to the environment. The six key elements according to the EU Nitrates Directive show how to save nitrogen for the farm and for the cultivated plants (food and feed), and thus reduce nitrogen losses to the air or to the water. The brochure lists the six elements of the Codes for Good Agricultural Practice under the Nitrates Directive:

1. Periods when the application of fertilizer is inappropriate
2. Application of fertilizer to steeply sloping ground
3. Application of fertilizer to water-saturated, flooded, frozen or snow-covered ground
4. Conditions for application of fertilizer near watercourses
5. Capacity and construction of storage vessels for livestock manures
6. Procedures for Fertilizer application, including rate and uniformity of spreading

Furthermore, this brochure includes tables with mean nitrogen values to enable nutrient and manure calculations at farm level, like average nitrogen contents of manure, average excreted nitrogen amounts per livestock category and volumes of manure storage capacities.

The target group for this brochure are farmers and agricultural advisors interested in improving the nutrient management of the farms.

1.4 Why is Nitrogen Management important and how do farmers benefit?

Pollution of soil, water and air by leaching and fertilizer run-off not only affects the environment but also human health of present and future generations. Responsible agricultural practices ensure clean drinking water and fertile soils for a secure food supply. A particularly important consideration for farmers is the financial aspect. Nutrient losses due to inappropriate fertilizer application lead to a waste of valuable farm resources. Efficient use of fertilizers saves additional costs for mineral fertilizers and ensures stable crop yields. This can lead to higher incomes for farmers and a more secure financial situation for family farms. Manure is a low-cost, valuable source of nitrogen on livestock farms.



Loss of nutrients ↓

Costs of artificial fertilizers ↓

Crop yields ✓

Farmer's income ✓

2. THE 6 KEY ELEMENTS OF THE CODE OF GOOD AGRICULTURAL PRACTICE ACCORDING TO EU NITRATES DIRECTIVE (91/676/EEC)

1.5 Periods when fertilizer application is inappropriate

What is it about?

Apply nutrients only during the growing season in suitable climatic conditions.

- ⇒ Target fertilizer application to periods when crops need nitrogen. This prevents nutrient losses to water (e.g. no fertilizer application in winter or during drought in summer)
- ⇒ There is no exact blueprint for determining these periods, as each region has specific requirements. It depends on agricultural practices, climate and soil conditions, when nutrient losses are most likely.



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INFLUENCING FACTORS TO DEFINE THE PERIOD:

1. Periods with low water infiltration rate: slaking, crust formation and water saturation of the soil.
2. Periods, when crop growth is just established or inhibited by cold, or when soils are left fallow.
3. Periods, when precipitation (including thawing) exceeds the water infiltration rate to the soil, depending on:
 - average monthly precipitation surpluses
 - temporal uptake patterns and uptake capacity of specific crop types
 - the presence or absence of cover crops and vegetated buffers
 - the use of irrigation.

What does this mean for my farm?

- ⇒ Define necessary storage capacity for manure storage to avoid manure application in these periods (Key element 5).

In North Macedonia

- it is generally not recommended to fertilize in late autumn and during the winter period, when the highest amounts of precipitation are expected and crops do not need nitrogen (November-February).
- Manure must not be applied in winter and early spring (between October 15 and March 15),
- The capacity of the storage vessels for manure should be at least sufficient for the quantities of fertilizer produced in the period, when its application is limited by weather and soil conditions (mainly in the winter period) (see → Key element 5).

Anonymus (2010), Ministry of Agriculture, Forestry and Water Management (2016)

1.6 Fertilizer application to steeply sloping ground

What is it about?

After fertilizer is applied to hilly or sloping land (slopes of 15% or more), rain or soil erosion can cause nutrient run-off (nitrogen and phosphorus). This results in the loss of important nutrients intended for plant growth. In addition, the washed-off fertilizers are carried into nearby water bodies and pollute them.

WHAT TO DO TO REDUCE THE RISK OF NUTRIENT SURFACE RUN-OFF:

- Establish areas with vegetation throughout the year (e.g. pastures instead of fields)
- Incorporate fertilizer quickly after application (especially for liquid manure, biogas manure, fermentation residues, non-stabilized urea fertilizers and non-dewatered sewage sludge)
- Splitting of fertilizer amounts (partial applications over time)
- Special protective measures for crops with particularly late spring development (e.g. beet, maize, broad beans, soybean): Cultivation across the slope or with other cultivation methods that prevent run-off (e.g. mulch and no-till), cross-ditches with plant cover



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Steeply sloping agricultural fields where fertilizer application can be problematic

1.7 Fertilizer application to water-saturated, flooded, frozen or snow-covered ground

What is it about?

Frozen soil and snow cover limit nutrient movement into the soil and greatly increase the risk of nutrients being carried into surface waters by runoff. The same is true for water-saturated soil. This often occurs after the land has been flooded due to unusually heavy rainfall or when rivers and streams overflow. Therefore, no fertilization should take place in such conditions. This applies equally to arable land and grassland. Furthermore, the use of heavy machinery in very wet conditions can lead to severe compaction of the soil.



In North Macedonia fertilizers should not be applied on agricultural areas, which are frozen, covered with a snow cover higher than 5 cm, saturated with water or flooded.

(Official Gazette of the Republic of Macedonia No. 02-9882/3, 2015, Ministry of Agriculture, Forestry and Water Management, 2016)

Here are a few indicators of unfavorable conditions for fertilization:

- **Water saturated soil:** the soil is so wet that it cannot absorb any more water, for example after heavy rainfall. It is recommended to check the weather forecast for the next 48 hours before applying fertilizer. This can prevent the loss of valuable fertilizer through run-off.
- **Flooded soil:** the ground is flooded due to overflowing watercourses and cannot absorb any more water. Fertilizer application in regularly flooded areas should be limited to the growing season when the crop uptake is high.
- **Snow-covered soil:** if less than half of the soil in the field is free of snow.
- **Frozen soil:** if the soil does not thaw during the day.

1.8 Fertilizer application near water courses

What is it about?

Buffer zones protect water bodies from fertilizer run-off. Therefore, avoid the direct entry of nutrients into surface waters by keeping a certain distance between fertilized area and surface water.

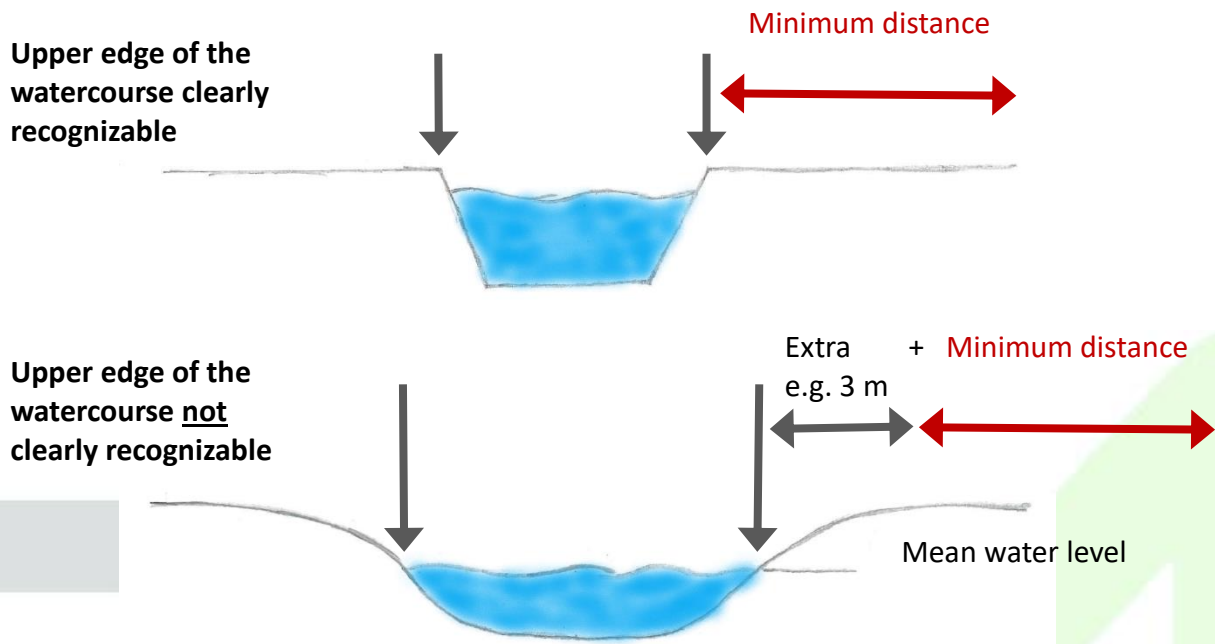
Recommendation:

Establish a permanent vegetation cover within approximately 3 m from the edge of the watercourse. This should not be plowed and should only be renewed every 5 years at most. This measure helps to prevent the loss of valuable fertilizer into the water.

Example: Buffer zone widths in Austria	Slope in %	Distance to standing water bodies	Distance to running water bodies
Arable field	< 10 %	20 m	10 m
	< 10 %	10 m (covered with living plants all year)	3 m (covered with living plants all year)
	> 10 %	20 m	5 m (covered with living plants all year)
Grassland	< 10 %	10 m	3 m
	> 10 %	20 m	5 m



Reference points for minimum distances from watercourses



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In North Macedonia fertilizers should not be applied:

- **Mineral fertilizers:** within **3 m** from the upper edge of surface waters and water courses
- **Organic fertilizers:** within **10 m** from the upper edge of surface waters and water courses

Official Gazette of the Republic of Macedonia No. 02-9882/3, 2015

1.9 Capacity and construction of storage vessels for livestock manures

What is it about?

Safe and secure manure storage to prevent water pollution from run-off and leaching into ground and surface water.

- ⇒ Condition of storage containers or pads: liquid-tight containers, concrete waterproof areas, controlled leachate discharge into a liquid-tight collection pit
- ⇒ Sufficient storage capacity prevents manure application at inappropriate times.



CALCULATION OF STORAGE CAPACITY

Tip: HOW TO CALCULATE THE CAPACITY OF THE MANURE STORAGE TANK



Manure accumulation amounts for each livestock category are included in the Annex

$$\begin{aligned} & \text{Manure production per animal per month} \times \\ & \text{number of animals} \times 6 \text{ months} \\ & = \text{Minimum storage capacity for 6 months (m}^3\text{)} \end{aligned}$$

- Storage capacity should be adapted to the longest period during which fertilizer application is not appropriate → Key element 1

- The recommended minimum storage capacity for manure on a livestock farm is 6 months
- Do not forget to include the amount of precipitation and water from cleaning processes

What does this mean for my farm?

Formulas and units for calculations:

- ⇒ Slurry: 1t = 1 m³
- ⇒ Solid Manure: Cattle: 0.83 t = 1 m³. Pigs: 0.91 t = 1 m³, Poultry: 0.5 t = 1 m³, Sheep/Goats: 0.7 t = 1 m³

Calculate the area of a manure pad:

$$\frac{\text{Total solid manure (m}^3\text{) for 6 months period}}{2} = \text{area of manure pad (m}^2\text{)}$$

In North Macedonia: Manure storage facilities should allow the accumulation

- of solid manure for 4-5 months,
- of liquid manure and slurry for 6-7 months,

although the storage period may actually be shorter. The larger capacity allows greater flexibility in planning the application of the fertilizer. The storage facilities should be constructed with an impermeable concrete base to prevent the liquid of the fertilizer from spilling, washing or leaking into the environment.

Ministry of Agriculture, Forestry and Water Management, 2016

IPARD III-Programme

„Investments in physical assets of agricultural holdings“:

- Manure handling systems (storage, treatment etc.)

Are subsidized by the rural development programme 2021-2027 (IPARD III-Programme)

IPARD III-Programme = Programme III (2021-2027) of the Instrument for Pre-Accession Assistance, <https://ipard.gov.mk/mk/pocetna/>

1.10 Procedures for fertilizer application, including rate and uniformity of spreading

What is it about?

Procedures for fertilizer application, including rate and uniformity of spreading, of both chemical fertilizer and livestock manure, which will maintain nutrient losses to water at an acceptable level.

⇒ The Nitrates Directive sets a maximum limit for the nitrogen amount applied from livestock manure: 170 kg N per hectare per year.

Tip: HOW TO CALCULATE THE TOTAL NITROGEN AMOUNTS OF LIVESTOCK MANURE AVAILABLE AT THE FARM PER YEAR



Nitrogen amounts per livestock category and year are included in the Annex

**Nitrogen excretion per animal × number of animals
= total Nitrogen (kg) in manure in one year**

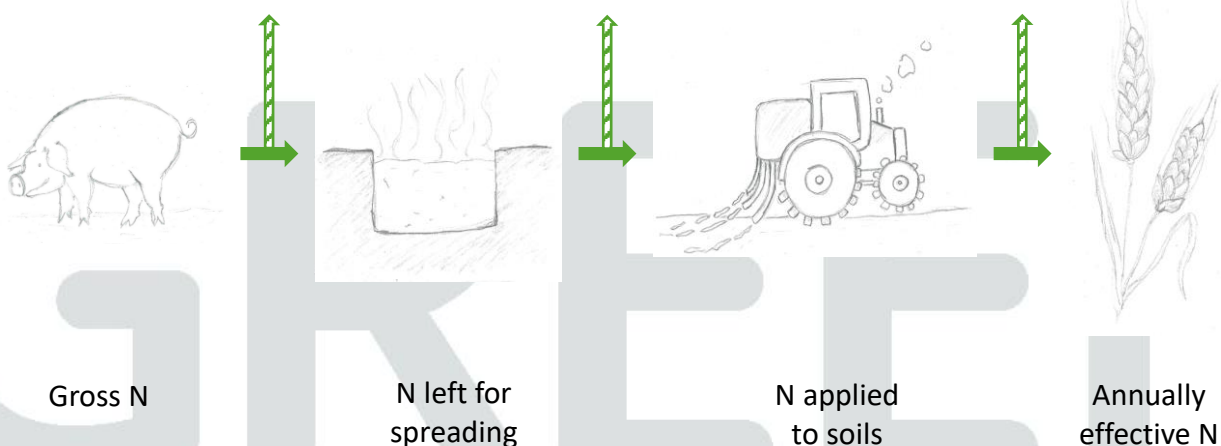
WHAT SHOULD BE TAKEN INTO ACCOUNT?

- Nitrogen excretion coefficients per animal category to calculate the nitrogen amounts available in manure
- Splitting of fertilizers
- Accuracy of fertilizer distribution: equipment must be adequate to portion and distribute fertilizers properly
- Incorporation of fertilizers
- Weather and wind conditions

Stable and storage losses

Losses during spreading

Delayed effectiveness of organically bound N



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In North Macedonia:

- Excessive watering should be avoided, as excessive irrigation leads to nitrate leaching into the groundwater
- Nitrate fertilizers should be applied in several small doses, consistent with crop harvesting, e.g. through the use of fertigation
- Fertilization should be done based on recommendations following soil analysis
- Fertilizer spreading equipment should pass a certification system to ensure proper functionality and evenness of fertilizer application
- The Nitrate Directive limits the application of manure to a maximum of 170 kg of pure Nitrogen

Official Gazette of the Republic of Macedonia No. 02-9882/3, 2015, Anonymus, 2010

LITERATURE

European Commission (1991). Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Online: <https://eur-lex.europa.eu/eli/dir/1991/676/oj/eng>

Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft (2022). Verordnung des Bundesministers für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft über das Aktionsprogramm zum Schutz der Gewässer vor Verunreinigung durch Nitrat aus landwirtschaftlichen Quellen (Nitrat-Aktionsprogramm-Verordnung – NAPV). Online: <https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20012132>

Hölzl, F.X. (2024). Ausbringungsverbote und Sperrfristende gem. NAPV sowie Abstandsaufgaben zu Oberflächengewässern incl. GLÖZ 4 und Gewässer-Definition. Landwirtschaftskammer Oberösterreich: Abteilung Pflanzenbau - Boden.Wasser.Schutz.Beratung, Linz.

Anonymus (2010). Guide to good agricultural and hygiene practices on farming (Minimum conditions for implementation of good agricultural practice). Macedonian language version.

Ministry of Agriculture, Forestry and Water Management (2016). Cross-compliance manual for the implementation of minimum conditions for good agricultural practice and environmental protection. prepared by Perica Ivanoski, Ivana Tsavirovska, Aleksandar Musalevski. Skopje.

Official Gazette of the Republic of Macedonia No. 02-9882/3 (2015). Rules for the list of special minimum conditions for good agricultural practice and environmental protection. Minister of Agriculture, Forestry and Water Management.

ANNEX: NITROGEN EXCRETION AND MANURE PRODUCTION IN LIVESTOCK

Nitrogen excretion coefficients and manure production quantities for livestock categories in North Macedonia. Data source: Nitrogen excretion coefficients: Rulebook CGAP North Macedonia (2015), Note: At the time of writing, no specific values for Nitrogen excretion for piglets, breeding boars, goats and turkeys for North Macedonia were available: for this reason, values from Montenegro are included in the table (Daily manure production/animal: Regulation on the principles of good agricultural practice for the application of fertilizers, "Official Gazette of Montenegro", No. 29/2014).

Livestock category	Nitrogen excretion in kg N per year per animal	Manure production per animal (m ³) per month SLURRY
Cattle		
Cattle less than 6 months	10.5	0.9
Cattle 6 - 12 months	21.0	0.9
Cattle 1 - 2 years	42.5	1.2
Adult Cattle (over 2 years)	70.0	1.7
Swine		
Piglets (less than 20kg)	1.6	0.03
Breeding sows	24.3	0.50
Breeding boars	32.0	0.7
Fattening pigs	12.0	0.25
Sheep and Goats		
Sheep	10.5	0.17
Goats	3.5	0.17
Poultry		
Broilers	0.2	0.004
Layers	0.3	0.007
Turkeys	1.7	0.03
Horses		
Horses	60.7	2.0

A free **Livestock Manure Calculator** (Microsoft Excel spreadsheet) is available under the following QR code to help you calculate the **manure storage capacity** and the **nitrogen amount in manure**:



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