AQUIFER PROJECT: “Innovative instruments for an integrated management of groundwater in a context of an increasing scarcity of hydrological resources”

Good Agricultural Practices

1. INTRODUCTION

The necessity of more information regarding aquifers, their monitoring networks and their sustainable management led to the creation of the Aquifer project. The Aquifer project aims to "capitalize, test, disseminate and transfer innovative practices for the preservation, monitoring and integrated management of aquifers, to assist them in making decisions regarding the management of groundwater resources, improve technology transfer to local actors, create new synergies and develop common tools in a context of scarce water resources and environmental threats." What sets this project apart from others is the fact that it studies both the state of water quality and the quantity of water existing in groundwater bodies, through the study of aquifer recharge management and the use of monitoring network and hydrological modelling. Another point to highlight is the creation of a website open to the public that helps decision making on good agricultural practices that prevent the degradation of aquifers and increase their water quality and quantity.

To make this project as complete as possible, several national and international entities joined forces: National Centre of the Geological and Mining Institute of Spain (IGME), Instituto Superior de Agronomia (ISA-UL), AR - ÁGUAS DO RIBATEJO, E.I.M., S.A., Comunitat d'Usuaris d'Aigües del Delta del Llobregat (CUADLL), Aqua-Valley, Serviço Nacional de Geologia, BRGM, Portuguese Water Partnership (PPA), Catalan Water Partnership (CWP) and the Community of Irrigators of Campo de Cartagena (CRCC).

In order for each entity to give its best contribution, there are different groups of activities, which are distributed among the different partners. The first group of activities aims to obtain a pilot aquifer monitoring network and a hydrogeological database. The second group is focused on hydrogeological modelling, aquifer recharge and on defining innovative solutions for water resources management. The third group is responsible for creating a decision support network for groundwater management and for exploring the limitations and difficulties of combined use. Finally, the last group defines innovative aquifer management practices in situations of scarcity and to create a transnational website with all this information available.

At the end of this project, a more complete database will exist, it will be possible to consider aquifer recharge and it will be possible to help agricultural producers and other consumers to correctly manage their water consumption.

This document aims to present in a simplified way the agricultural practices that promote the preservation of water resources, both from the point of view of consumption and of fertilization and fertilizer storage.

2. GOOD AGRICULTURAL PRACTICES TO PREVENT AND REDUCE POLLUTION IN WATER BODIES

For documents like this one to be useful, these good practices need to be applied, and this is only possible if all this information reaches the farmer. Currently the farmer wants to get the maximum yield from the crop, which means only the water and fertilizer costs necessary for the crop to have maximum productivity. But for the crop yield to be maximum, it is necessary to work with higher than ideal values so that in case of failure or error, the crop is not harmed.

Other factors to consider are technology and legislation. Legislation is generally respected, due to existing controls. Regarding new technologies outside the legal obligation, these can make the farmer's work more efficient and reduce water and nutrient losses. Technologies and new practices are only promoted by private entities, which inform the farmer of the whole procedure, how it works and its advantages.

Currently, the farmer tries to keep informed and adheres to most of the practices, but for that it is necessary to have a guide and to be known to everyone.

This guide contains different measures that prevent or lead to a reduction of the concentration of pollutants in water bodies, whether surface or underground. These measures are associated to different factors such as irrigation management, the application and handling of fertilizers, equipment cleaning, riparian vegetation management and many others. As some of the measures mentioned have a legal obligation, the file has been divided into measures with legal obligation and measures without legal obligation. These measures are divided into different categories: Irrigation management, Water use, Fertilization and fertilizer storage, other farming practices.

2.1. Legally binding measures

2.1.1. Irrigation management

- Irrigation allocation: The volume of water used during irrigation should be stipulated considering the needs of the crop and soil characteristics, such as "water retention capacity, its degree of humidity at the time of irrigation and the thickness of layer to be moistened". (Ministério da Agricultura, Despacho nº. 1230/2018, 2018)

- Uniform application of irrigation water: irrigation water should be applied uniformly in order to avoid areas of excess water that may lead to surface runoff or "deep seepage movements". "Sprinkler irrigation, drip irrigation or coveting" should be used in sloping areas reducing surface runoff. (Ministério da Agricultura, Despacho nº. 1230/2018, 2018)
- Make irrigations before the plants reach water shortage, this way the plant will absorb more water and nutrients reducing residual nitrogen and phosphorus. (Ministério da Agricultura, Despacho nº. 1230/2018, 2018)
- Estimate crop irrigation needs: Estimating irrigation needs and considering weather forecasts and phenological state of the crop, leads to a reduction of water consumption and loss of water and nutrients, both by infiltration and runoff. (Ministério da Agricultura, Despacho nº 1230/2018, 2018)

Irrigation management adapted to each soil type

- "Adopt the most appropriate irrigation method": the irrigation method should be chosen based on local characteristics: soil, land topography, land area, water quality and abundance, crop requirements and local climatic conditions. There are some measures adapted to different soil types:
    - "On soils with high permeability and in all areas of high or moderate risk of losses of nitrates, phosphate ions and/or soluble organic phosphorus compounds", gravity irrigation methods should not be used as water losses by leaching are high. Sprinkler irrigation or localized irrigation is recommended.
    - In medium-textured soils (loamy and silty-loamy), there is no limitation regarding the type of irrigation, if it is done in a timely manner, with the right amount of water and in a homogeneous way.
    - When dealing with fine-textured soils, in low-risk areas, any irrigation system can be used if measures are taken to reduce soil compaction, as these soils are "endowed with poor permeability, low infiltration rates and high retention capacity for water" (Ministério da Agricultura, Despacho nº. 1230/2018, 2018)

2.1.2. Method of applying inorganic fertilizers

- "Apply nitrogen and phosphorus at the most appropriate times and in the most appropriate forms and in quantities according to the expected production": The amount of fertilizer to apply must be estimated based on the expected production of the crop, the availability of irrigation water and the specific needs of the crop, so that excesses of nitrogen and phosphorus are avoided and washed into water bodies. (Ministério da Agricultura, Despacho nº. 1230/2018, 2018)
- In forage crops, it is not allowed to apply "manure, sargasso, guano, sludge and composts, slurries and nitrogenous chemical fertilizers between 1 November and 1 February". (DGADR, 2018)
- No fertilizer application is allowed after the harvest of spring-summer crops (Ministério da Agricultura, 2012)
- The application to the soil of fertilizers, during the vegetative cycle, is not permitted when the soil is in a situation of excess water, the indicated thing being to wait for it to normalize the water content in the soil (Ministério da Agricultura, 2012)
- When fertilizing sloping land, it is necessary to pay attention to the slope and mode of application in order to avoid surface run-off of fertilizers (Ministério da Agricultura, 2012).
- For the application of fertilizers in places near water bodies, it is necessary to respect the minimum safety distances from the river or stream bed, as referred to in the Decree-Law. (Ministério da Agricultura, 2012)
- For the application of fertilizers in locations near groundwater abstractions, it is necessary to respect the minimum safety distances from the abstraction, as referred to in the Decree-Law. (Ministério da Agricultura, 2012)
- A fertilization plan must be carried out based on soil and irrigation water analysis, leaf analysis and expected yield. (Ministério da Agricultura, 2012)
- Farms must perform soil and irrigation water analysis to determine: the concentration of nitrogen, phosphorus, potassium and magnesium in the soil, the soil pH and the nitrate content in irrigation water. These analyses must be done annually (Ministério da Agricultura, 2012).
- The amount of nitrogen to apply to the crop should be calculated in advance based on the analyses carried out and the needs of the crop. (Ministério da Agricultura, 2012)

- The mode of application of the fertilizer must allow maximum uptake of the nutrients in the fertilizer and the fertilizer must be applied as uniformly as possible. (Ministério da Agricultura, 2012)

2.2. Measures with no legal obligation

2.2.1. Irrigation system and its maintenance

- Efficient irrigation systems and localized irrigation systems with the capacity to optimize the amount of water that is irrigated: Optimization of water quantity allows only the necessary amount of water to be consumed and avoids excessive application of water. Over-application of water can lead to soil erosion, soil compaction and the washing and drawing down of nutrients into existing water bodies. Localized irrigation systems also allow only the necessary area to be irrigated, avoiding water and nutrient losses through leaching (EDIA, 2020).
- Fertigation with interspersed application of nutrients: fertigation allows the application of fertilizer dissolved in water in a precise location and in the desired quantity. This application of fertilizer should be after the application of 20% - 25% of the irrigation appropriation and stop when 10% - 20% of the amount of water is missing. Fertigation allows "reducing leaching losses and maximizing plant uptake". (EDIA, 2020)

2.2.2. Water use

- Give preference to supply from surface water bodies: In places where it is possible to use water from surface water bodies, preference should be given to the use of surface water bodies avoiding over-exploitation of groundwater. The use of only groundwater bodies can cause problems not only in supplying farms but also in supplying the population. By splitting consumption between the two types of water bodies, it is possible to maintain the water level of aquifers in case of scarcity. (EDIA, 2020)
- Respect the guidelines and measures stipulated during the drought period (EDIA, 2020)

2.2.3. Fertilization and fertilizer storage

Method of applying inorganic fertilizers

- "Fractionate the recommended amount of nitrogen": nitrogen fertilizer should be distributed considering the recommended dosage and should be applied in the "seasons when the crops need it most" (Ramos, et al., 1999).
- Nitrogen fertilizers should not be applied if rain is forecasted for the following 2 days, and it is recommended to consult the meteorological services. Nor should nitrogen fertilizers be applied before irrigation. Non-compliance with these indications may lead to the dragging of fertilizers into the water bodies (Ramos, et al., 1999).
- In the presence of waterlogged soils, wait until the soil reaches a "state of normal moisture" before applying fertilizers. (Ramos, et al., 1999)
- In autumn/winter crops, only 1/3 of the total nitrogen fertilizer should be applied at sowing. It should be applied as top dressing and in "ammoniacal form during periods of lower rainfall" (Ramos, et al., 1999).
- In irrigated annual crops, fertilization should be spread over the whole crop cycle (Ramos, et al., 1999).

How to apply organic fertilizers

- Rational use of livestock effluents
    - The application of manure and slurry should not be carried out within 35-50m of sources, wells or water abstraction for human consumption (Ramos, et al., 1999).
    - Slurry distribution should be carried out in bands and close to the soil surface, with the adaptation of the distribution bar of the cistern being necessary (Ramos, et al., 1999)
    - An analysis bulletin and technical opinion of the organic effluents must be requested. (Ramos, et al., 1999)

Storage and handling of fertilizers

- Storage and handling of chemical fertilizers

- Both solid and liquid fertilizers should be stored in waterproof and dry places. These should be located more than 10 meters from "rivers and streams, drainage ditches or pipes, wells, boreholes or springs". (Ramos, et al., 1999)

- Liquid fertilizers should be stored in corrosion-resistant tanks and "stored on a base sufficiently resistant to the weight of the filled containers". All fittings (pipes, filling valves and others) must be corrosion resistant and properly cleaned out of the period of use. (Ramos, et al., 1999)

- All operations involving liquid fertilizers (e.g., grout preparation and filling of tanks) must be carried out "more than 10 m from water lines, drainage ditches or pipes, wells, boreholes or springs". (Ramos, et al., 1999)

- Store livestock effluents correctly
  - The collection and storage areas for slurry, manure and other organic correctives should be waterproofed on both walls and floors, preventing infiltration into the soil. These rooms should be protected from rain. The waterproofing, the impermeable base, prevents leaching of nitrate and should be maintained to avoid leakage. (Ramos, et al., 1999)

  - Manure storage places should "be at least 10 m away from water courses or drains, or 50 m away from springs, boreholes or wells whose water is for human consumption or livestock watering". (Ramos, et al., 1999)

- Protecting water quality from pollution by plant protection products
  - "Prepare the grouts more than 10 meters away from wells, boreholes, springs, rivers and streams, ditches or drainage pipes." (Ramos, et al., 1999)

  - "Never contaminate ditches, wells or watercourses with surplus grout or wash off application material." (Ramos, et al., 1999)

  - In case there are syrup or equipment washing surpluses, these can be applied on vegetated land after being properly diluted. (Ramos, et al., 1999)

  - Give preference to plant protection products that have lower risk of contamination of groundwater, products advised in integrated protection. (Ramos, et al., 1999)

- It is necessary to respect the restrictions concerning "the use of plant protection products in areas vulnerable to groundwater contamination and in protection perimeters of water abstractions intended for public supply". (Ramos, et al., 1999)
- The higher doses mentioned on the label should not be applied on light soils or soils with little organic matter. (Ramos, et al., 1999)

2.2.4. Other Practices

- Use of cover crops in rotations: Production of a cover crop after the main crop helps to reduce the risk of nitrate leaching as it can reduce the concentration of N in the soil. The cover crop will take up the N produced during decomposition and mineralization.
- Introducing trees for afforestation and hedges in the landscape: Planting trees "around agricultural fields" maý reduce the leaching of NO_3 as this nitrogen is absorbed by them. The ability to absorb nitrogen will depend on the size and location of the tree or hedge and the amount of nitrogen, hydrological flow paths and weather.

3. BIBLIOGRAPHY

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