# EUTROMED PROJECT

**LIFE 10 ENV/ES/511**
**2011-2015**

eutromed
Prevención de la eutrofización por nitrógeno agrícola

## LAYMAN REPORT

**EUTROMED Project has demonstrated the effectiveness of a technology manufactured from vegetable fibres such as esparto and straw, to prevent nitrate pollution from agricultural sources in surface water, contributing to potential solutions to this environmental problem spread throughout Europe**

Biorolls and layers made from vegetable fibres installed in olive gullies -cultivated in slopes of semiarid zones with poor vegetal cover- have been shown to act as filter for the nutrients dissolved in surface runoff and as barriers for the loss of fertile soil.

**Coordinator:**

Diputación de Granada

**Associates:**

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BonTerra Ibérica S.L.

**Co- financier:**

JUNTA DE ANDALUCIA
CONSEJERÍA DE AGRICULTURA, PESCA Y MEDIO AMBIENTE

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**LIST OF ABBREVIATIONS:**

**DIPGRA: Provincial Council of Granada.**
**UGR: University of Granada.**
**PSUR: *Paisajes del Sur* S.L.**
**BTI: *Bonterra Ibérica* S.L.**
**$BOD_5$: Biological Oxygen Demand.**
**QOD: Chemical Oxygen Demand.**
**SS: Solids in suspension.**
**Ntotal: Nitrogen total.**
**Ptotal: Phosphorous total.**

# 1. CONTEXT AND ENVIRONMENTAL ISSUES

***Reservoir in The Vega of Granada.***

**Accumulation of nitrate in surface water is one of the causes of eutrophication** and constitutes an increasing environmental and health problem in the world. The Vega of Granada is seriously affected by this pollution problem. Main causes are attributed to inadequate agricultural and cattle raising practices, among which we can cite the excessive application of nitrogen fertilizers, both organic and mineral. The diffuse nature of this pollution makes it very difficult to prevent.

The Directive 91/676/CEE of the Council regarding the protection of waters against nitrate pollution from agricultural sources, has as main goals the reduction of pollution caused by nitrates of agricultural origin, the elaboration of codes of good agricultural practices addressing the farmers, as well as the implementation of **action programs** for the zones categorized as vulnerable and **control programs** for the monitoring of their efficiency.

The **EUTROMED project provides solutions for this environmental problem, by combining preventive actions with corrective measures**. The Project has shown the effectiveness of a technology which retains an important part of the nutrients dragged by runoff, preventing them from reaching the surface waters, and therefore, diminishing the risk of pollution.

The area of operation consisted of a micro basin of 276 ha, a tributary of the Juncarón stream (in the municipality of Deifontes), which in turn drains its waters into the Vega of Granada, a zone categorized as vulnerable to nitrate pollution from agricultural sources.

***Project´s Area of Operation.***

This is a zone dedicated to olive cultivation with slopes greater than 10%, poor soils, no vegetal cover and scarce irrigation in a Mediterranean climate zone, which favours erosion and the formation of gullies. Excessive and inadequate utilization of nitrogen fertilizers causes the dragging of nutrients dissolved in runoff through the gullies towards the surface water masses.

***View of olive groves in Deifontes, Granada.***

## 2. OBJECTIVES

*Example of a gully formed in olive groves without vegetal cover.*

**The main objective of the Project** has been to develop and demonstrate a sustainable method for the reduction of nitrogen levels in surface runoff, in agricultural lands in Mediterranean climate zones, avoiding nitrate pollution in surface water bodies.

*Awareness activities for farmers.*

**The specific goals** defined at the beginning of the project are listed as follows:

- To reduce the pollution of nutrients in surface waters by: 70% nitrates, 50% Ntotal, 50% $BDO_5$, 70% SS, 50% QDO, 30% Ptotal.
- To reduce the use of fertilizers by farmers by 10% the first year and up to 30% by the end of the project.
- To achieve a reduction of soil erosion by 80%.
- To obtain a biomass increase of approximately 5 t/ha/year.
- To raise awareness among farmers in accordance with the principles of territorial stewardship.
- To publish communication and dissemination materials which allows the transfer of the project to other territories.

# 3. METHODOLOGY

***Organic layers and biorolls stabilized on the soil.***

## ACTIVITIES FOR THE PROMOTION OF LOCAL RECEPTIVITY AND SIGNING OF VOLUNTARY AGREEMENTS.

Firstly, a number of briefings were convened with local farmers to introduce them to the Project, raise interest and achieve their participation. The result of these sessions was the exact determination of the zone of operation (based on participant farmers) and the signing of Voluntary Agreements among owners and partners of the EUTROMED project for the implementation of technology in agricultural parcels and development of several preventive measures.

***Briefing for farmers members of "San Isidro de Deifontes" Cooperative.***

## DEFINITION, PRODUCTION AND INSTALLATION OF TECHNOLOGY IN THE AREA OF OPERATION.

Afterwards, in the sub- basin of the Juncarón stream, the treatment of 61 gullies with vegetal filters -systems consisting of biorolls, organic layers and nitrophilous plants- was carried out.

***Stacked biorolls.***

Biorolls and layers are made of vegetable fibres (esparto and straw). Biorolls are placed perpendicular to lines of runoff on the slope, and layers are placed over the bed of the gully (without vegetal cover). A number of flexible stone gabions are installed -at a certain distance from each other- to secure the fixation of biorolls and layers, preventing them from being dragged away by water. In the backfill of biorolls, nitrophilous plants adapted to local conditions have been introduced, such as *Santolina chamecyparisus, Rosmarinum officinalis, Lavandula latifolia, Thymus mastichina* and *Thymus zyggis.*

*Bioroll installed in a gully with nitrophilus plants.*

*Gully treated with model 3.*

According to the slope and depth of the gullies, **4 models of vegetal filters were designed,** represented in the diagram as follows:

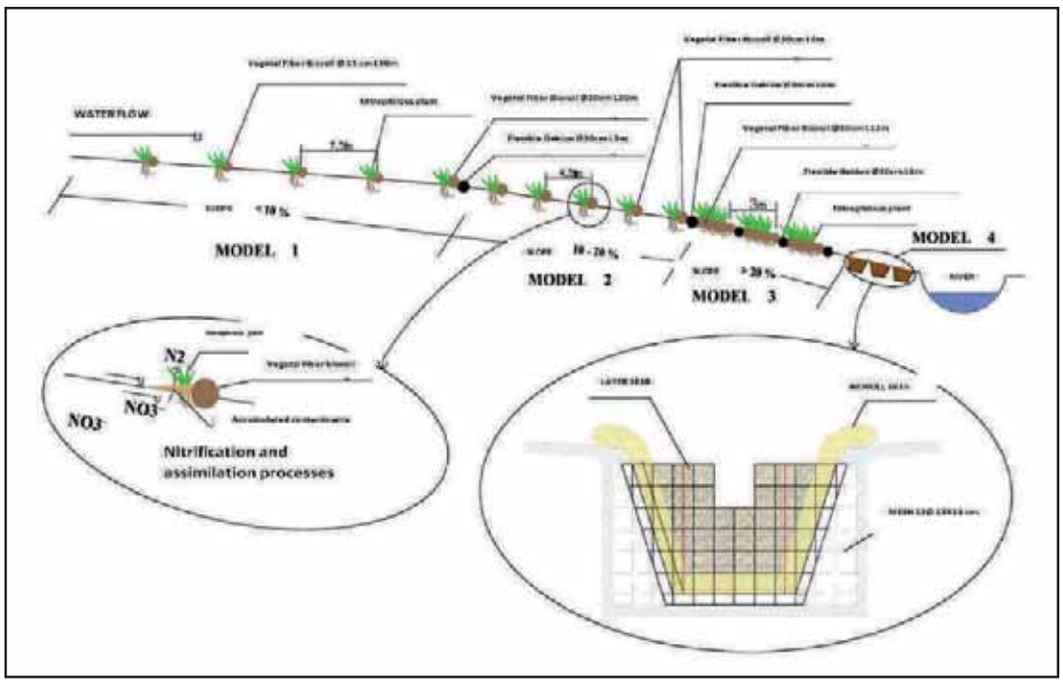



*Diagram of the 4 models of Vegetal FIlters Designed.*

*Systems installed following Model 4.*

With reference to models 1, 2 and 3, both diameter and bioroll length are subject to variation, as well as the distance between them, with the presence or absence of layers and frequency of flexible gabions.

**Model 4 is different** from the other three models: it was built using palisades of corrugated steel -forming small dams-, and it was designed to provide a solution to the more deepened and encased gullies, which could not be filled with surrounding materials.

## MEASUREMENT AND MONITORING OF SYSTEM EFFECTIVENESS.

To assess **the effectiveness of these system**s as nutrient filters, a number of retention and storage systems for surface runoff were installed in several parcels, as is shown in the image.

Each parcel contains a gully treated with vegetal filters and an untreated gully, used as a control. The composition of runoff has been analyzed in 10 sample rounds. Deposits were emptied after collection of samples, to follow the evolution of the biorolls' behaviour after every rainfall over time. Moreover, soil samples were collected for thorough examination.

***Retention systems for runoff water installed.***

To assess the impact of the treatments at sub-basin level, when there was enough flow, water samples were collected from the Juncarón stream, where all the surface runoff -coming from zones treated with vegetal filters- is discharged.

Likewise, a follow up has been done on the evolution of the development of parcel biomass and soil erosion, to measure differences between treated and controlled gullies. For biomass monitoring, parcels of 1 square meter have been installed, where all vegetal material was mowed and weighed at the end of the spring season. For the erosion control, steel pikes were painted with Fluorescent markers, in order to measure variations in soil level.

## COUNSELLING, AWARENESS AND TRAINING OF FARMERS.

Simultaneously, preventative work has been carried out through the following actions:

1) **Individual counselling** for farmers participating in voluntary agreements for the use of a software platform, which promotes the optimization of fertirrigation in their cultures, avoiding in this way, excessive use of fertilizers and other malpractices.

   Advice and techniques for the promotion and management of vegetal covers, biorolls conservation and control of soil erosion have complemented the contents of the counselling sessions.

2) **Training seminars** addressing farmers' needs, regarding topics related to olive cultivation: soil, water, nitrogen fertilization and erosion control.

***Seminar on Control Erosion held in Albolote.***

## EDITION OF INFORMATIVE MATERIAL AND COMMUNICATION ACTIONS.

Provisions of communication and outreach have accompanied the Project throughout its development. The website has been central to show the progress of the Project, and all the dissemination material has been uploaded there: quarterly newsletters -scientific and technical, brochures, dossiers, outreach reports, practical guides, training guide, etc. A number of briefings have been held addressing the general public and the project has been presented at numerous conferences and seminars, both national and international, of topics related to the project.

***Practical Guides published.***


***Shortguides handed out in the dissemination sessions.***

***CD including practical guides in pdf.***

***Dissemination brochures.***


***Website www.eutromed.org***

# 4. RESULTS

*Growing olives in Deifontes, Province of Granada.*

## INVOLVEMENT OF FARMERS, REDUCTION IN THE USE OF FERTILIZERS AND IMPLEMENTATION OF GOOD PRACTICES.

A total of 69 farmers got involved in the EUTROMED project through the signing of voluntary agreements. Forty-two percent of farmers have signed the whole agreement, including -besides all preventive measures- the implementation of technology in their exploitations. All their parcels are located within the sub-basin tributary to the Juncarón stream, which embraces an area of 276 has. The remaining 58 % have participated in the Project through the development of prevention measures such as the implementation of good agricultural practices, use of software platforms and participation in training activities. This second group owns approximately 600 ha, where the prevention measures have been carried out.

Among the tools available in the market for the optimization of fertirrigation, Orcelis Fitocontrol was selected and afterwards adapted to the particular characteristics of the cultivation targeted by the project. Up to 90 % of farmers involved have applied the recommendations provided for this appliance regarding olive fertilization, which reduced the use of nitrogen fertilizers by 32%.

Diagram 1 shows the summary of the nitrogen fertilization per hectare produced during different campaigns carried out throughout the development of the Project.

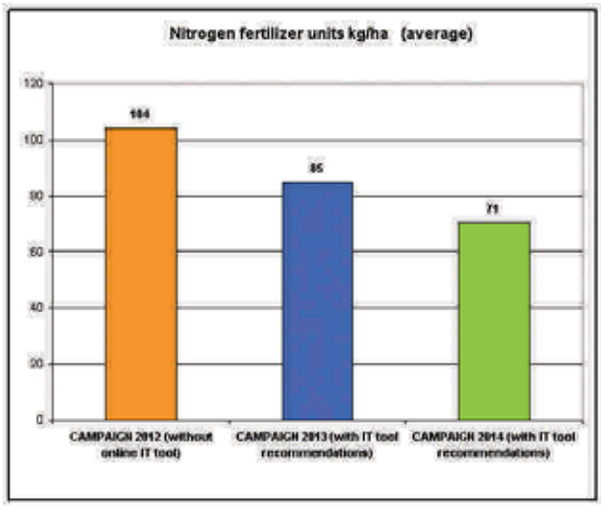
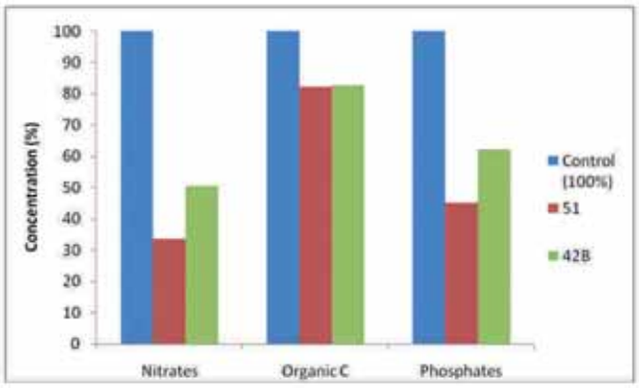


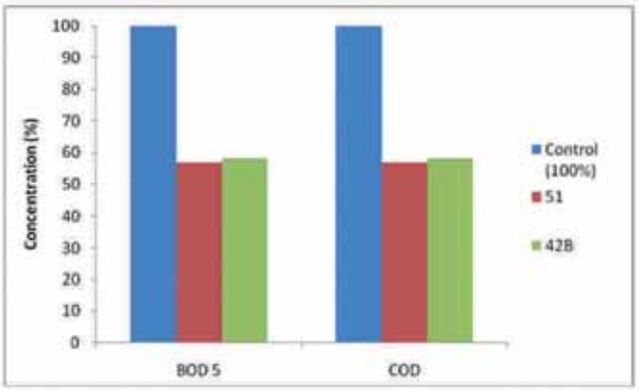

***Diagram 1. Nitrogen fertilization implemented in the operation zone and reduction percentage for successive campaigns.***

## EFFECTIVENESS OF VEGETAL FILTERS IN PREVENTING NITRATE POLLUTION OF SURFACE WATERS.

The measurement and monitoring actions have shown the efficacy of biorolls in the retention of nutrients dissolved in runoff water, the diminishment of fertile soil losses and the increase of the production of biomass. According to the data obtained from the analysis of runoff water in the zone of operation, the vegetal filters installed are acting as bio-filtering barriers, diminishing

approximately 60% of the nitrates, 50% of the phosphates, 20% of organic carbon and almost 50% of $BDO_5$ and QDO in runoff running through them, retaining these nutrients and avoiding the pollution of receptive surface water.




***Diagrams 2 and 3. Reducction of nutrients in surface runoff from gullies treated compared to untreated gullies.***
*(100% represents the concentration of control parcels).*

A very significant result has been the reduction of nitrate concentration observed in the Juncarón stream, where surface runoff from both treated slopes is drained. Considering the values obtained from "Juncarón half" presented in the following table, it is shown that the whole of the preventive and corrective actions have succeeded in diminishing the concentration of nitrates by 60%.

| Sampling points (December 2013) | Nitrates (mg/l) | Phosphates (mg/l) | Organic carbon (mg/l) |
|---|---|---|---|
| Juncarón half | 85,54 | 3,53 | 50,40 |
| Juncarón final | 74,86 | 1,84 | 62,61 |

| Sampling points (October 2014) | Nitrates (mg/l) | Phosphates (mg/l) | Organic carbon (mg/l) |
|---|---|---|---|
| Juncarón beginning | 32,75 | 4,29 | 20,53 |
| Juncarón half | 34,96 | 0,63 | 41,87 |

***Tables 1 and 2. Concentration of nutrients in the Juncarón stream after analyses carried out during december 2013 and october 2014.***

Soil analyses carried out included the texture study and quantification of assimilable phosphorous concentration, oxidizable organic matter, total nitrogen, pH and assimilable potassium. From the obtained results, lack of remarkable differences between treated and untreated parcels was clearly demonstrated, which indicates that the presence of biorolls does not modify nor affect mineral richness or soil structure. It is evident that, within the treated zones, a soil cover is developing with stable characteristics; slight modifications observed in one of these covers do not imply a negative alteration of the habitat.

Simultaneously, the denitrifying activity of the soil has been studied. It has been deduced that, both in treated and untreated parcels, there is a considerable amount of biological activity producing a high denitrifying capability. Likewise, it does not appear that the installation of these systems is causing any significant alteration in biological activity.

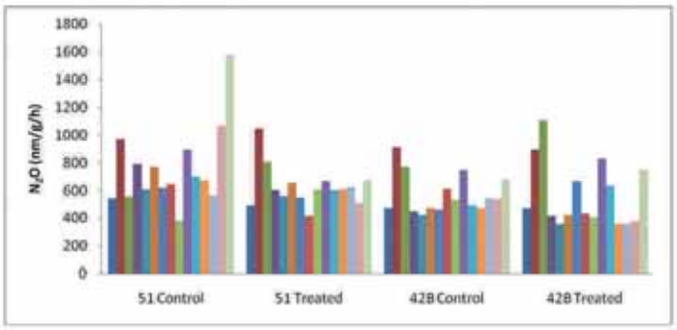



***Diagram 4. Denitrifying activity present in the soil, expressed as the production of $N_2O$ (nm/g/h).***

## REDUCTION OF FERTILE SOIL LOSS.

The monitoring of soil erosion has been difficult and not all the pikes could provide information. From the data obtained we see that soil loss on untreated parcels is 33,3 $cm^3/m^2$, whereas the soil gained on treated parcels is on average 458,3 $cm^3/m^2$, which gives an efficiency index over average losses of 1.475 %. If only the records from trusted pikes are used, this percentage diminishes to 150% of reduction in soil loss in treated parcels compared to controlled parcels, a value that continues to be pretty significant.

## INCREASE IN THE PRODUCTION OF BIOMASS.

Biomass production has presented important differences over the years, coinciding with the alternation of rainy and dry years. According to the table, the sum of generated biomass plus the biomass introduced with the biorolls throughout the implementation of the project has approached 5 tons per hectare, which was the final goal of the project.

| | SAMPLE OF FRESH BIOMASS (05/06/2013) | SAMPLE OF FRESH BIOMASS (12/06/2013) |
|---|---|---|
| Average of treated parcels ($g/m^2$) | 632,11 | 172,53 |
| Average of control (untreated) parcels ($g/m^2$) | 217,41 | 124,07 |
| Difference ($g/m^2$) | 415,41 | 48,47 |
| Difference (Kg/ha) | 4.154,11 | 484,67 |
| Biomass introduced with treatments (Kg/ha) | 338,15 | |
| **TOTAL BIOMASS ACCUMULATED (Kg/ha)** | 4.976,93 | |

**Table 3. Data of biomass production in EUTROMED´s operation zone.**

## RATIO COST-BENEFIT.

To carry out the cost-benefit analysis, costs incurred by the introduction of vegetal biorolls in parcels studied as well as the use of a software platform for the fertirrigation optimization were compared to the direct benefits obtained from such installation regarding the elimination of nitrogen from water bodies, as well as the indirect and non-quantifiable benefits.

Regarding the costs, they have been computed in euro currency, corresponding to production, installation and replacement of vegetal filters (biorolls, layers, fences, gabions and nitrophilous plants), as well as the hiring of a software platform for the optimization of fertirrigation. Of all the benefits obtained from vegetal filters, the most important has been the decrease of nitrates in the Juncarón stream, the main water body receptor in the project' area of operation; having diminished by an average of 46 mg/l in one year of treatment.

| | |
|---|---|
| Cost of software platform (100 users) | 40.000 €/3 years = 13.333 €/ year |
| Kg of N eliminated thanks to the utilization of the software platform | 33kg/3 years * 276 ha = 3.036 kg |
| Cost of treatments per year (290.259,63 € in three years) | 290.259,63 € / 3 years = 96.753,21 €/year |
| Reduction of nitrate concentration in Juncarón stream- 1 year | 46 mg/l |
| Nitrogen eliminated (mg/l) | 0,2259 x 46 mg/l Nitrates = 10,40 mg/l |
| Flow of Juncarón stream | 606.800 $m^3$ per year |
| Kg of N eliminated per year | 606.800 $m^3$ x 10,40 mg/l = 63.107,2 Kg of N |
| **Cost-benefit= Cost of Software platform + Cost of treatment (€)/kg N eliminated+ saved** | 110.086,51 €/66.143,20 kg N= **1.66 €/Kg N** |

***Table 4. Calculations to obtain the ratio cost-benefit of the treatment.***

The obtained value was compared to the cost of other type of treatment for Nitrogen elimination (Table 5). It can be noted that the cost of vegetal filters is comparable to the cost of very basic methods used in agriculture and cattle- raising which do not include the use of any technology. Therefore, it can be stated that, through the use of vegetal filters, high levels of efficiency can be reached at low cost.

| METHOD OF NITRATE ELIMINATION | COST (€/Kg N) |
|---|---|
| Increase the manure and/or sludge storage capability to prevent nutrients runoff. | 1,56 |
| Integrate the use of fertilizers and manure to reduce nutrients charging. | 4,85 |
| Reduce the number of animals to achieve an acceptable relation N- P to reduce nutrients charging. | 31,34 |
| Install systems of sewage treatment to prevent nutrients runoff. | 170,14 |

***Table 5. Examples of some methods os nitrogen elimination and their costs.***

Besides the direct benefits, indirect and non-quantifiable benefits have been taken in account. The indirect benefits are listed as follows: the increase of total biomass obtained by 5 tons per hectare, the reduction of soil-loss by 150% and the generation of 25.131 hours of hired labor, translated into 3.141 labour days of 8 hours. Among non-quantifiable benefits we can name the savings that this system involve, taking into account a number of studies calculating costs derived from the qualitative decrease of rivers, lakes and those caused by eutrophication of surface water.

**In conclusion, with the installations used by the EUTROMED Project, high retentions of nitrates can be achieved at very low expenses.**

# 5. LONG-TERM BENEFITS AND IMPACTS.

*Growth of vegetation cover in the roads.*

## ENVIRONMENTAL

### Prevention of nitrate pollution.

Several analyses conducted throughout the Project have shown that installed systems retain a good portion of the nutrients dissolved in surface runoff, in such way, that there is a diminishment of nutrient-dragging by 60% less, in the case of nitrates. The spread of this technology throughout the territory, together with the application of good practices in nitrogen fertilization will impact positively and tangibly on the quality of surface water.

*Olive groves in sloping lands with proper management of vegetation cover.*

### Control of fertile soil loss.

Biorolls, layers and fences also act as barriers to the loss of fertile soil. Gullies formed in soils without vegetal cover in semiarid zones usually evolve into deeper gullies if preventive measures are not taken. Biorolls and little dams which form the fences retain the particles of dragged soil, shaping the gullies into terrace-like configurations, diminishing their depth by retaining the soil and, thus reducing the erosive force of water.

### Promoting the development of vegetation cover.

In these extremely arid territories, seeds and roots find great support in the biorolls and layers, as an adequate substrate to enhance their growth. They stay fixed in the interstices, which allow them to grow in poor or eroded soils. The development of such vegetation protects the soil from the rainfall impact, limiting its erosive power and enhancing its filtration into the soil; its root system development helps the retention of soil particles, the improvement of their structure and the increase of organic matter content. Without a doubt, biorolls and layers facilitate the initial implantation of vegetation in such arid terrain as the one we are currently working with. Later, their proper management will ensure good

maintenance under conditions that avoid competition for the crop.

## ECONOMIC

### Cost reduction in fertilizer application.

The implementation of the recommendations made by the computer program has implied a reduction by over 30% in Nitrogen fertilizers applied to crops. The utilization of a smaller amount obviously implies less expense but not a reduction in the crop yield, since it has been demonstrated that a good portion of the excess of applied nitrates is lost in the surface runoff without being absorbed by the plants.


***Orcelis Fitocontrol Software Platform.***

### Adding value to local products.

Biorolls and layers are made of vegetal fibres, mainly esparto and straw. These are local resources, with potential for territorial development, which can be exploited and valorised for the manufacture of these systems. Biorolls are associated with the installation of Stone gabions and native plants with a good capability for nutrient fixation. All these factors generate businesses at local level, linked to sustainable development and the restoration and conservation of the natural environment.

***Nursery of forest plants- PSUR.***

## SOCIAL

### Positive effects on employment.

The spatial and temporal spread of this technology and related good agricultural practices brings positive effects on jobs based mainly in production, manufacture, installation and maintenance of biorolls. Raw materials for this technology are based on local vegetable and mineral products whose exploitation promotes sustainable development of rural zones. Later, the manufacture, transport, installation and maintenance of structures require a large amount of labour. Within the framework of the corrective actions implemented by EUTROMED project, which involved the treatment of an area of 276 hectares, 25.131 hours of direct labor have been generated over 44 months of the project. The expansion of this alternative to other territories would proportionally increase the numbers. On the other hand, counselling, training sessions and outreach sessions have also involved the creation of qualified employment positions.

**Participation and increasing awareness among farmers.**

The working methodology developed during the implementation of the project has promoted the involvement of farmers. EUTROMED has been introduced as a volunteer project, not mandatory, which could be freely accessed. There has been continuous outreach regarding the stages of the project, the environmental problems the project has faced, their solutions, the commitments made by the parties, the benefits, etc. On one hand, individual counselling has been provided, approaching particular problems and the necessities of each exploitation in a personalized way. On the other hand, seminars and sessions have been organized to encourage debate, the exchange of experiences, and clarification of doubts by experts in the field. In the seminars, diverse topics affecting agriculture have been approached, and several good practices experiences in other exploitations have been visited. All this has contributed to boost interest among farmers, which has promoted their involvement and awareness.

Without doubt, EUTROMED Project has worked with farmers at all times because it understands that the success regarding its environmental goals depends on a change in the practices and work of farmers, in such a way that the Project does not finish, but it is pushed beyond and it becomes a seed for the adoption of good agricultural practices compatible with soil conservation and the prevention of nitrate pollution.

***Farmers participating in a workshop on soil erosion.***

***PSUR workers installing systems in the field.***

***BTI factory in Campotéjar.***

# 6. CONCLUSIONS

***Olive groves in sloping lands with proper management of vegetation cover.***

The **EUTROMED Project** has combined preventive and corrective measures to face the problem of nitrate pollution in surface water and the loss of fertile soil whose main causes are excessive and inadequate fertilization and agricultural labour malpractices.

**Preventive measures** have achieved a reduction in the quantity of applied fertilizer units, adapting them to the real requirements of the crop, which has led to a decline in the amounts of nitrates present in the soil, susceptible of being dragged by surface runoff.

***Workshop on Manufacture and Installation of Firewood Bundles and Biorolls for Restoration of Gullies.***

Corrective measures have been proven to achieve a high level of effectiveness in nutrients and contaminants retention (nitrates, phosphates and organic carbon) dissolved in runoff water passing through. Biorolls, layers and fences manufactured from vegetable fibres (mainly esparto fibre) together with vegetal cover, act as barriers, preventing an important part of nutrients from being dragged away to the surface water.

Besides the prevention of nitrate pollution, **other environmental benefits** derived from these systems have been shown, such as the reduction in fertile soil loss and an increase in vegetal cover development. Also, we must add the social and economic benefits that the Project has brought, such as the positive effects on employment, adding value to local resources and the involvement of farmers in changing agricultural practices.

**Installed systems** will remain in the operation zone and will be integrated completely in the soil. The partners of the project will continue monitoring after the finalization of the project. During the following years, systems will keep working as filters, diminishing the contaminant charge reaching the surface water in a significant way, and acting as support for vegetation, enhancing the development of the vegetal cover.

To facilitate the replicability of the experience in other territories, practical guides of great technical value have been edited, which will be available on the project's website, at least until the year 2020.

# DATA OF THE PROJECT

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### Duration of the project:

From September 1st, 2011 to April 30th, 2015.

### Co- financier:

JUNTA DE ANDALUCIA
CONSEJERÍA DE AGRICULTURA, PESCA Y MEDIO AMBIENTE

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