

# Geospatial Tools for Olive Oil Mills' Wastes (OOMW) Disposal Areas Management

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**Abstract.** LIFE+ project “Strategies to improve and protect soil quality from the disposal of olive oil mills’ wastes (OOMW) in the Mediterranean region-PROSODOL” aims towards the development and application of technologies for the protection, improvement and remediation of soils which are threatened by the degradation, coming from the disposal of olive oil mill's wastes. In this effort and among others, several geospatial application tools were presented and implemented aiming at the effective monitoring of soil quality and wastes disposal areas management. The project was based on the collection of more than 1000 soil samples throughout the course of the project which were chemically analysed in order to indicate the most significant soil parameters that could most suitably describe soil degradation due to OOMW disposal. Based on the above results, a geospatial monitoring system application tool was implemented, where users (individuals or services) can enter measurements (spatial points) of these indicative soil physico-chemical parameters at various time intervals and soil depths and monitor the fluctuation of the values through time. Results are indicated through predefined diagrams that have predefined zones (orange and red) depending on the degree of alert that needs to be signaled to the users. In addition, the soil parameters were mapped with respect to the depth, date and temporal variations of their spatial distribution (spatial surfaces). Furthermore, the diffusion of these parameters in the subsurface was also studied. Interpolated surfaces were created and integrated within another geospatial web based map application tool. Interpolated surface maps can be viewed simultaneously with the above topographic and satellite maps, providing a possible overview of the diffusion of the parameters in the subsurface and thus the risk-level in the vicinity of the waste disposal areas to the users. A further verification of the diffusion of the underground pollution was also monitored through the application of electrical resistivity tomography (ERT) techniques. The geospatial monitoring tool application is available for free download from the Web site of the project ([www.prosodol.gr](http://www.prosodol.gr)). The soil parameters and organic compounds content as well as other geological, hydrological and land use features, for all disposal sites of the three main areas of interest (former municipality of Nikiforos Fokas in Rethymno, Crete (Greece), Albenga region and Loano commune-municipality (Italy), form the spatial background information provided by the PROSODOL project. A prototype (ArcGIS for INSPIRE) Geoportal, integrating a Geodatabase with a Schema compliant with the INSPIRE Directive was employed for carrying out the whole mapping and the transforming process of PROSODOL's spatial data information to compatible INSPIRE Map (View) Services.

**Keywords.** Olive Oil Mills Wastes (OOMW), geospatial tools, LIFE project, Rethymno, surface interpolation, monitoring tool, electrical resistivity tomography, INSPIRE geoportal.

## 1. Introduction

The Mediterranean region accounts for no less than 97% of the world's olive oil production due to the favorable climatic conditions. Greece holds the third place worldwide in olive oil production

and the island of Crete contributes approximately 5% to the total world olive oil production. The production procedure of olive oil generates large volumes of Olive Oil Mill Wastes (OOMW) with high organic load and rich in inorganic constituents which may lead to pollution of soil and water resources and therefore environmental degradation. The OOMW are usually disposed in evaporation ponds which are rarely of proper size and wastewaters often overflow affecting neighbouring systems (soil, surface and groundwater) and other professional activities of the residents (agriculture, livestock farming). The base of the ponds is permeable and thus, the probability for groundwater and deep soil contamination is high. Consequently long-term disposal of waste, without necessary monitoring and protective measures may cause changes in the physico-chemical parameters of the surrounding ecosystems, with the risk of future non-tissue degradation of the environment.

The above issues are addressed by the LIFE+ project "PROSODOL" which investigates the type and nature of the chemical residues of OOMW, explores technologies for the protection and monitoring of soil degradation/pollution and searches for means of its improvement and remediation. To achieve these goals, several geospatial tools were developed aiming towards the effective monitoring of soil quality and wastes disposal areas management. Moreover, older waste sites often lack of reliable geological or artificial barriers and depositional information, to minimize the possibilities of further environmental damages. Among the diverse methodologies to monitor the OOMW pollution, the geophysical method in terms of Electrical Resistivity Tomography (ERT) has been also used for monitoring the changes of the physical characteristics of the subsoil over time identifying the diffusion of the contaminants. The problem of environmental degradation and waste management are of major concern of earth scientists and the local authorities.

## 2. The soil monitoring system application

In the PROSODOL project, the development and implementation of a Soil Monitoring System was necessary, in order to enhance the control of targeted areas, as well as others with similar activities, by monitoring several basic chemical parameters which reflect the wastes' disposal activity in the areas of interest. The aim of the soil monitoring system is to provide to the end users (public or private body) a handy tool for evaluating the degree of risk in the vicinity of the OOMW disposal areas. Since among European countries, but also worldwide, Spain and Italy are the two leaders in olive oil production, whereas Greece holds the third place, the monitoring system tool is designed and implemented in four languages, English, Greek, Italian and Spanish.

Below is a description of the functionality of this application tool.

The design process of the Soil Monitoring System Application tool consists of three basic principles:

- Specification of the most important soil physico-chemical parameters for evaluating the degree of risk of the waste disposal areas
- Specification of the limits and range of risk levels (range of values), corresponding to "red" and "orange" flag zones.
- Design of an interface that satisfies specific user needs, such as inserting, editing and searching functionalities of waste disposal areas chemical measurements, as well as presenting graphically the risk assessment results.

The whole application was designed and implemented with the Microsoft .NET framework enhanced with the capability of monitoring one or even more measurements on different waste disposal areas, and capable of use for a larger scale services, rather than private use only (backing up and restoring measurements data via XML<sup>1</sup>).

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<sup>1</sup> <http://www.w3schools.com/xml/default.asp> (last date accessed: 22 Mar 2012)

Eleven soil physico-chemical parameters were selected in the end based on their ability to be used as indices to define soil's degradation/pollution (Table 1). Furthermore, the limits and the value range of the risk zones (red – high risk, orange – moderate risk) are denoted in the specific table columns (written references that contributed to estimate those ranges are presented to References section).

**Table 1.** Soil physico-chemical parameters including their limits, red and orange zone ranges. Parentheses correspond to the bibliography.

Physico-chemical Parameters	Orange zone	Red zone	Limits
Electrical Conductivity, (mS/cm)	>2-4 <sup>(11)</sup>	>4 <sup>(12)-[16]</sup>	0.2-40
Organic Matter, %	> 5.0 <sup>(12)-[16]</sup>	>20 <sup>(30)</sup>	0.05-55
Total phenols, (mg/kg)	>40 <sup>(11)</sup>	>150 <sup>(31)</sup>	0.1-700
Total Kjeldahl Nitrogen, (%)	> 0.3 <sup>(12)-[16]</sup>		0.02-3.00
Available P-Olsen, (mg/kg)	29-59 <sup>(2), [3], [12]-[16]</sup>	> 60 <sup>(3)</sup> (potential high P mobility)	1-500
Exchangeable K, (cmol/kg)	>1.2-2.0 <sup>(12)-[16]</sup>	>2.0 <sup>(17)</sup>	0.1-30
Available (DTPA)-Fe, (mg/kg)	>20-40 <sup>(9)</sup>	> 100 <sup>(5)</sup>	1-400
Total Cr (mg/kg)	64-200 <sup>(6), [7]</sup>	>200	5-1000
Total Ni (mg/kg)	30-100 <sup>(11), [18], [19], [21]-[24]</sup>	>100	5-500
Total Mo (mg/kg)	3-4 <sup>(11), [22], [24]</sup>	>4	1-200
pH	>8.0 <sup>(1)</sup>	>8.5	4.0-9.5

In order to evaluate the degree of risk in the vicinity of a waste disposal area, the user needs to insert values to some or all of the above soil physico-chemical parameters, and evaluate graphically the results upon an XY point diagram, the red and orange risk zones, are also presented.

Moreover, the user needs to insert other measurement data, such as location properties, date recording information, area coordinates and submit them to the system. Special provision has been made to secure the proper entry of data by disallowing the entry of values that exceed certain range limits or conditions. Only when input measurement information passes all constraints and preconditions, can the user can submit data to the system. Edits can take place according to all preconditions and constraints mentioned earlier for any measurement field attribute, value or text description, before applying the changes to the system. Moreover, the system provides the user the ability to delete a whole measurement from its database (or dataset). The user has also the ability to search for measurements data of targeted areas, submit selected information, configure certain measurement fields, and search for measurements that are stored in the system. The inserted soil physico-chemical parameters' values which are stored in the system's database can be viewed graphically on a XY diagram, presenting in the most meaningful way if the corresponding measurements exceed or are within the parameter limits (risk degree). The user not only can search measurements with certain criteria and needs, but also has the potential to export the search results information (measurements found) in an Excel file format sheet (Figure 1).

Measurement Id	Area Code/Name	Date	Depth	Latitude	Longitude	Village	Prefecture	Description	Electrical Conductivity	Organic Matter	Total Phenols	Total Kjeldahl Nitrogen	Available P-Olsen	Exchangeable K	Available (DTPA)-Fe	Total Cr	Total Ni
2	NF2	16/12/2010 12:38:20 μμ	50	35.236987	25.145236	sdafa sdg	asdf asdf	asd fasa fhdshg	40	1	56	2	85	5	48	73	421
3	NF3	16/3/2011 12:00:00 ημ	60	35.236589	25.321458	asd fasa fhdshg	asdgas fdfas hsgdh ghsgdh	blablablaba	37.62	12.3	58.3	2.8	235.2	25.6	368.3	452	12.3

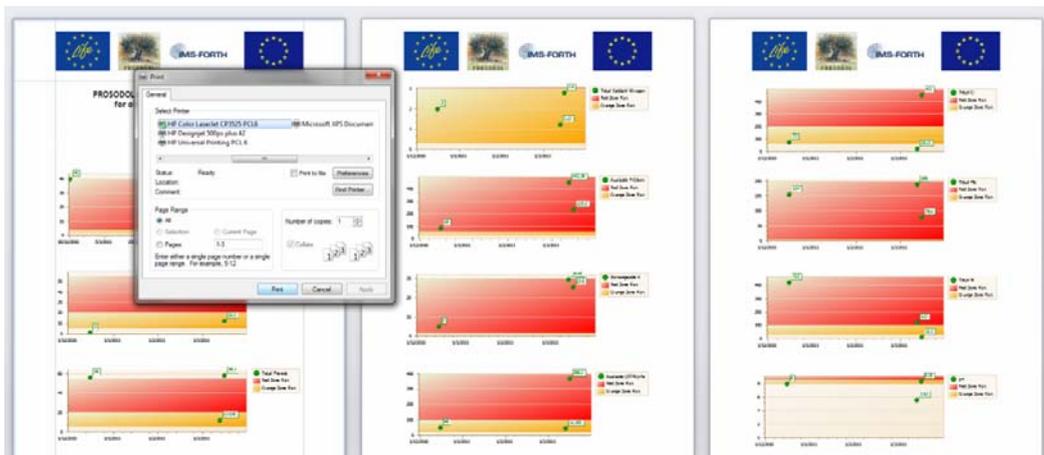


Figure 1: Top: Inserting measurement data in the Monitoring System tool. Middle: Searching measurements' information in the Monitoring System tool. Bottom: A graphic visualisation of chemical parameter measurements stored in the database of the Monitoring System tool. Result of the search functionality.

### 3. Surface analysis & interpolation methods

The soil monitoring system application concerns the monitoring of selected physico-chemical indices at a specific location. How can one however monitor the dispersion of various physico-chemical elements in a wider area? In order to address the specific issue, physico-chemical parameters that were measured in many soil samples, collected from the areas under study and from different soil depths, were used to create surfaces of the distribution of different physico-chemical parameters that represent the possible diffusion of their values and the degree of risk in the vicinity of the waste disposal areas. The chemical parameters values were mapped with respect to the depth and date of samples collection, allowing the study of the temporal variations of their spatial distribution and their diffusion across the soil profile.

The Inverse Distance Weighted (IDW) interpolation method produced the most satisfying results among the interpolation algorithms that were tested. IDW calculates cell values by averaging the values of sampling points in the vicinity of each cell based on distance

$$Z_j = \sum_{i=1}^n \frac{z_i}{d_{ij}^2}$$

where:  $Z_j$  is the interpolated value at node  $j$ ,  $d_{ij}$  is the distance between the grid node  $j$  and its neighboring node  $i$  and  $z_i$  are the neighboring points.

In order to obtain valid interpolated surfaces, the creation of surfaces was allowed only when more than 4 known values were available for interpolation. In cases where the measured values were less than 4 it was not possible to interpolate surfaces and therefore no results were produced.

Aiming towards the creation of an easy and understandable user interface, surfaces were implemented in the WEB\_GIS application of PROSODOL web portal. In order to achieve such integration into a Map API, such as Google API or Google Earth API, flash maps techniques (Flash Builder software) were employed, so that the user can view the interpolated surface area images simultaneously above a topographic/satellite map provided by those APIs. After consideration of the time based functionality, which the user can view the chemical parameters diffusion in a subsurface over time, Google Earth API was chosen as the most appropriate to use, since it handles integration of time tagged images via XML, a language designed to transport and store information data. Regarding the interpolation process, the ModelBuilder tool of the ArcGIS Desktop was chosen to create the interpolated surface maps.

Several steps and processes were studied carefully prior to the design of the model construction of interpolated surfaces. The way to design a model is by building and connecting processes. A process is simply a tool plus its variables. A variable is either a data variable that references our data (layers, shape files of measurements information), or a value variable, which is anything else, such as numbers and text strings. Variables are connected to tool parameters. The ArcToolbox provides all the necessary tools that the model needs. Several processes (tools) need to be performed in order to achieve the resulted interpolation surfaces. The first step for the whole interpolation process is to define the date and depth of a measurement for the interpolated output map file. In the following step the interpolation process takes place. At this point it has to be noted that the interpolation of a surface, in other words, the diffusion of a physico-chemical parameter in an area, has no meaning above a radius or a distance from the sampling points. For this reason a "mask" is necessary in order to determine the interpolated area boundaries. The mask is actually a polygon that surrounds the area under study and only inside this polygon the surface interpolation will be processed. The mask is provided to the Model as a layer or shape file. At this phase of the model building, the entire interpolated surface, with the corresponding mask areas, depending on the measurements (more than 4) according to depth, date and physico-chemical parameter selection is materialised. Finally, a symbology layer file is needed to provide the tag of the range of values, which denotes the degree of risk with a colour scheme as shown in Figure 2. Knowing the normal

and the maximum acceptable values of a soil parameter [34], the potential risk could be assessed by a colour code included in the tool.

In every process step, ModelBuilder constructs the derived layers temporarily and only the final layer (the interpolated, masked, symbology accompanied layer) is stored, in order to provide it as an input to the *Layer to KML* process, which constructs our final KML file, namely an XML format file suitable for the Google Earth API application. The Google Earth API is a JavaScript API which allows embedding Google Earth, a 3D digital globe, into the PROSODOL Web site. Using the API, KML files can be loaded, allowing us to build a 3D map application. The particular, API allows the time plug-in, where time information contained to the derived KML files (as a feature), can be introduced to the plug-in and can be attached as a map view.

The implementation of the map application is quite straightforward; and it was handled with JavaScript over PHP pages of the PROSODOL web site. By selecting the user defined measurement, measurement's depth, and submitting the information to the application, the corresponding interpolated surface map is loaded. In Figure 2, the interface of the map application is presented. These interpolated surface images are pre-rendered, in order to reduce the time cost of creating them on the fly.

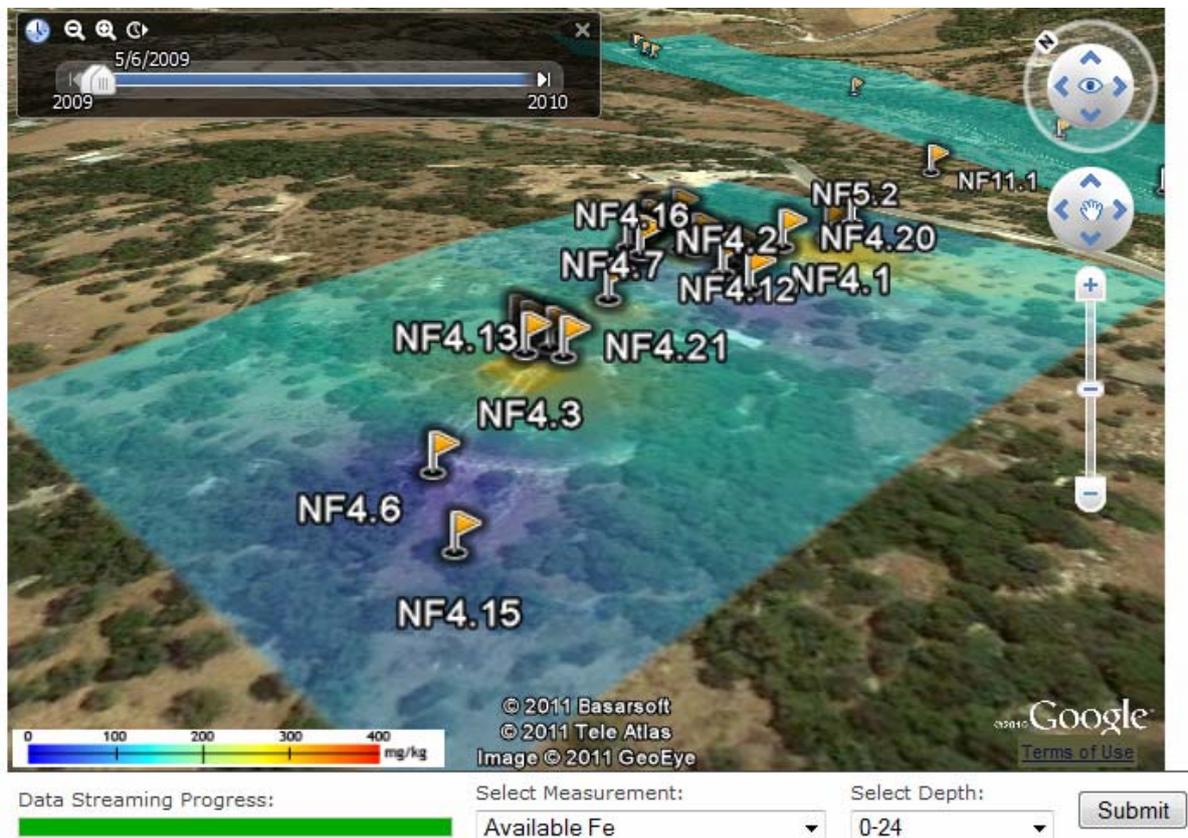


Figure 2: The User Interface of the 3D Google Map application indicating the surface distribution of the chemical parameters (in this case for available Fe) in terms of the date of sample acquisition and depth.

#### 4. Geophysical approaches: electrical resistivity tomography

Except for the frequent soil sampling and the subsequent physico-chemical analysis of the samples, geophysical techniques were also tested as a faster way of monitoring the diffusion of the soil parameters on surface- and deeper soil layers. The ERT monitoring experiment focused on a private property designated as an experimental site of PROSODOL project (Figure 3) which is a

large field (1ha) with almost 5% slope and contains two evaporation ponds for OOMW disposal with dimensions 32m x 4.20m x 1.70m and 30m x 44m x 1.75 m, respectively. Apart from the use of the two ponds, direct disposal of OOMW on soil takes place every 2–3 days between March and June every year. The site is located along the road connecting Rethymno and Roustika in the Prefecture of Rethymno.

A drill hole was opened close to the larger evaporation pond (Figure 3) and a plastic piezometer was installed inside the borehole that reached the depth of 16 meters from the ground surface. A multi-clone cable was manufactured for the purposes of the measurements required, which could drive simultaneously up to 48 outputs. The cable was attached on the outer surface of the plastic piezometer, gradually during its installation in the borehole. The cable outputs were placed on the plastic tube in equal separations every 0.4m and the lead leaf covered each output by surrounding the tube. Each lead leaf was tightly fixed with plastic clamp ensuring the maximum connection between the cable output and the lead leaf. Totally 36 electrodes were placed inside the borehole starting from the depth of 2m below the ground surface and the reaching the bottom of the borehole.

The ERT monitoring measurements were made in terms of surface-to-borehole mode. Stainless steel electrodes were used for the surface measurements and the length of the surface branch of the survey was 18.8 meters. The surface electrodes were placed along two vertical lines at equal spaces every 0.4 meters. Dipole-dipole and gradient array configurations were employed to capture the surface, borehole and surface-to-borehole apparent resistivity measurements. The gradient data were measured in a forward and reverse mode to evaluate and assess the noise level of the measurements. The time lapse resistivity data from totally 5 monitoring phases were collected from January until May of 2011. The preliminary results indicate that the level of noise of the measurements (based on the forward and reverse potential readings measured with the gradient array) is less than 2%. Based on this error level, during the pre-processing stage, almost 6% of all the monitoring data were removed since they exhibited unrealistic high or low resistivity values.

Each phase of the ERT monitoring data were processed individually with a standard inversion algorithm that could account for the surface-to-borehole field measuring mode (32). Similar parameters were used in the inversion of the data where the software converged to a resistivity model after 5-7 iterations and a Root Mean Square (RMS) error of less than 4%. In general, for all the reconstructed models a thin high resistivity layer (~20cm/backfill material) seems to overlay a more conductive layer (clay and marl) and a deeper resistance layer (clay with sand). The image inside the borehole shows generally a conductive material. In order to have a better insight regarding the time-lapse variation of the subsurface resistivity, difference images were extracted between the first phase (reference phase) and the remaining ones based on the simple rule  $\frac{T_x - T_1}{T_1}$ ,

where  $T_1$  is the resistivity inverted model of the first phase and  $T_x$  the inversion models for phases 2, 3, 4 and 5. The ERT inversion models (Figure 3) indicate a resistivity variation of +/-30% through the different monitoring phases. The decrease in resistivity values could be attributed to the movement of the conductive pollutant through the sandy marl of the area.

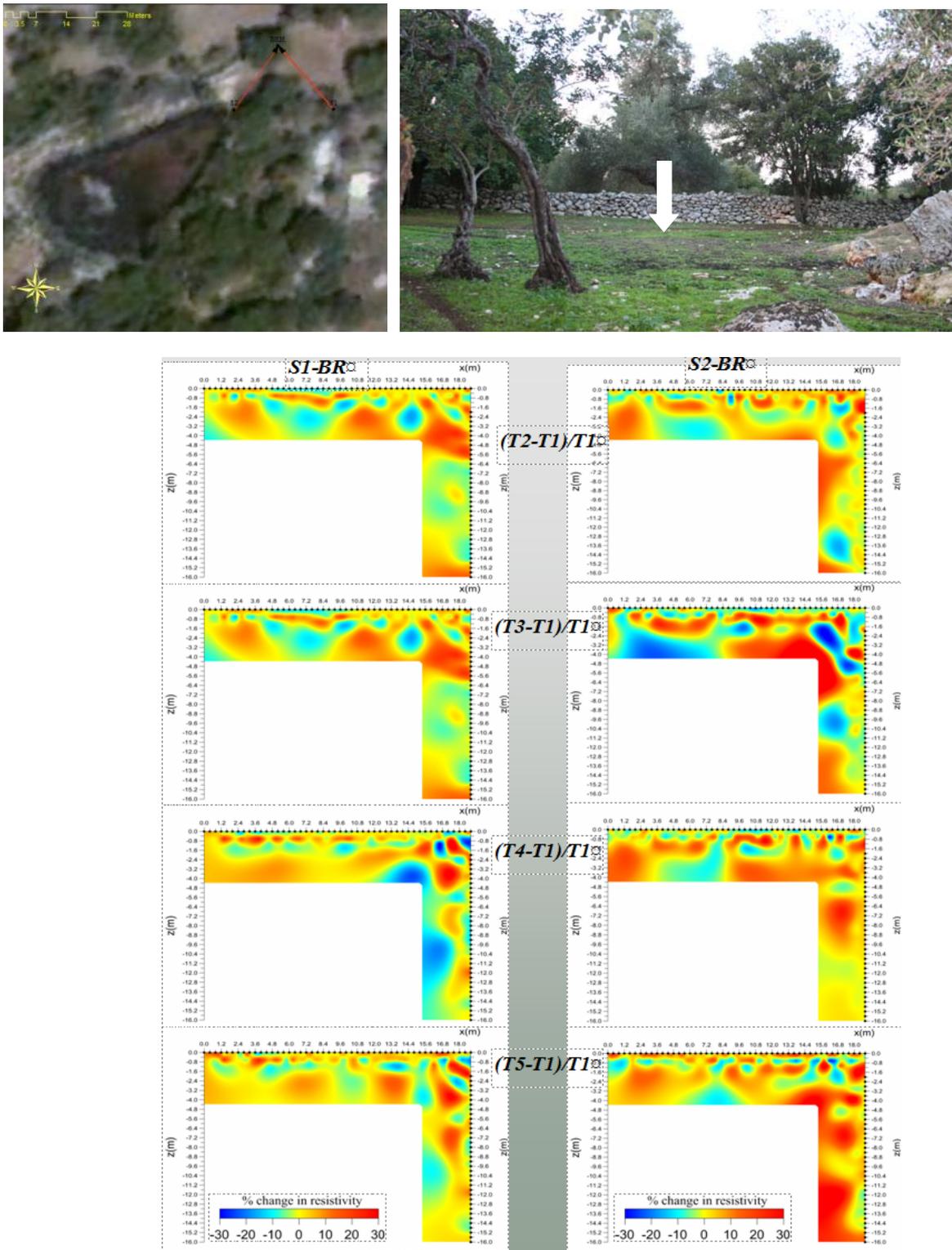


Figure 3: Top (left): Satellite image of the larger evaporation pond of the OOMW site where the geophysical ERT monitoring measurements were conducted. UP (right): The white arrow indicates the place where the borehole was drilled. Bottom: Preliminary results of the difference inversion of the ERT data collected along lines S1-BRH and S2-BRH for the five time phases. The results are plotted in terms of percentage relative change of the model resistivity of each phase with respect to the reference phase.

## 5. Spatial data conformity to the INSPIRE directive

PROSODOL is an environmental project of LIFE Programme, and as such, all spatial data concerning the project must be conformed to the INSPIRE Directive (EU). The INSPIRE Directive entered into force on the 15th May 2007, establishing an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment.

The INSPIRE Directive is based on the infrastructures for spatial information established and operated by the 27 Member States of the European Union. The Directive addresses 34 spatial data themes<sup>2</sup> needed for environmental applications, with key components specified through technical implementing rules. This makes INSPIRE a unique example of a legislative “regional” approach (33). To ensure that the spatial data infrastructures (SDI's) of the Member States are compatible and usable in a Community and trans-boundary context, the Directive requires that common Implementing Rules (IR) are adopted in a number of specific areas: Metadata, Data Specifications and Network Services. Metadata is information describing sets and services of geospatial data and make them possible to be found and used. For example, metadata for a geospatial set give us information on when it was created, who is the creator, what specifications might have been used to create the additional information. In the context of Metadata for spatial data and spatial data services, the standards EN ISO 19115, EN ISO19119, and ISO 15836 (Dublin Core) have been identified as important standards. Data Specifications must be governed by the 34 spatial data themes and are subdivided in the three Annexes of the directive (see INSPIRE Directive - Data Specifications). Annex-I is approved as an Implementing Rule while Annex-II and Annex-III data specifications are currently under construction. Finally, the Network Services are actually web services that need to be implemented.

The INSPIRE Directive requires a community geo-portal to be established and the Member States shall provide access to their infrastructures through the geo-portal as well as through any access points they themselves decide to operate. The current version of the *EU INSPIRE Geoportal* is a prototype geo-portal and allows for discovery and viewing of spatial data sets and services. Its aim is to identify issues related to its implementation and accessing distributed INSPIRE services, to help towards the development of the operational geo-portal. The INSPIRE Geoportal currently accesses a limited number of discovery and view services and therefore only a few metadata for spatial datasets and services may be found and viewed.

The *European Commission Metadata Editor* was designed to help the EU Member States to create metadata according to the INSPIRE implementing rules as mentioned in section Implementing Rules. One can fill in the necessary metadata fields and he is able to store the metadata in an XML file form. Thus, this file can be used to describe the metadata of various spatial data sets or even services according to the INSPIRE Directive. Certainly if the metadata already exists as such a file, then one can examine whether this file is compliant with the INSPIRE directive through the online *Metadata Validator*.

*ArcGIS for INSPIRE* provides a suitable solution including capabilities to ensure INSPIRE compliance supporting data, services, and metadata. Data are stored in the provided data models of the INSPIRE Annex-Themes implemented as an ESRI geo-database. This provides an ideal foundation for use and publication via ArcGIS Server. The core of the ArcGIS for INSPIRE is the “INSPIRE Services” component for ArcGIS Server. It is used for publishing Annex-Themes (currently only Annex-I Theme) as a geo-database. The extension expands the functions of an ArcGIS Server and integrates “INSPIRE View” and “INSPIRE Download” services as additional option into the existing service options.

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<sup>2</sup> <http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2/list/7>

The ArcGIS for INSPIRE Extension provides an essential element, the Geodatabase Schema, which implements the abstract INSPIRE data models (Annex-I Theme), in other words, objects such as database tables, feature classes and domains that form the creation of a Geodatabase for INSPIRE Annex-I data Models. Having the INSPIRE compatible geo-database schema, the next step is to create the corresponding INSPIRE layers for the PROSODOL spatial data and map services. INSPIRE data themes that are currently available are those that implements the Annex-I Theme data models (ex. “Geographical names”, “Cadastral parcels”, “Hydrography”, etc). This limitation results in the need to map the PROSODOL’s map services layers, to those that are currently available from the Annex-I data theme. The spatial data information of PROSODOL map document layers is added manually to the appropriate INSPIRE geo-database tables in order to fill in the information of the corresponding INSPIRE Maps layers.

In the attempt to develop the IMS/FORTH INSPIRE Geoportal, several valid available tools were used, which can support the INSPIRE conformity of the PROSODOL Spatial Data information, as well as for the Metadata of the implemented data (view and discovery) services. The Geoportal currently represents metadata and services for the PROSODOL project but it is intended to be updated with more information over time. IMS/FORTH INSPIRE Geoportal is accessible either from the PROSODOL’s website, or by addressing the URL <http://www.ims.forth.gr/geoportal> (last date accessed: 24 April 2012) (Figure 4).

The IMS/FORTH INSPIRE Geoportal provides an easy and convenient way to find, view and share geospatial data and metadata within the framework of the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive. The Geoportal is based on the ESRI Geoportal Server which is a free, open source product that enables the discovery and use of geospatial resources. The ArcGIS for INSPIRE Extension also gives to the core of the ESRI Geoportal (thus the IMS/FORTH INSPIRE Geoportal) the ability to add an INSPIRE View Service Metadata network resource via the embedded (INSPIRE) Metadata Editor. The visiting user may access the Geoportal and search or browse the PROSODOL project’s spatial data. In Figure 4, the search functionality of the Geoportal is presented, including some of the available options like 1) free text search, 2) zoom to the corresponding map layer, 3) visualisation of the results area, 4) detailed information of the geospatial data service that is in conformity with the INSPIRE Directive, 5) clearance of the search form field and 6) provision of the INSPIRE Metadata of the geospatial data service in an XML file.

The screenshot displays the INSPIRE Geoportal interface. At the top, there is a navigation bar with 'HOME', 'SEARCH', and 'BROWSE' options, along with a 'LAUNCH MAP VIEWER' button. The main content area shows the metadata for a service titled 'PROSODOL - Forestry for Municipality of Nikiforos Fokas, Greece'. Under the 'Identification' section, the 'Unique Resource Identifier' is listed as [http://okeanos.ims.forth.gr/ArcGIS/rest/services/PROSODOL/GREECE\\_FORESTRY/MapServer](http://okeanos.ims.forth.gr/ArcGIS/rest/services/PROSODOL/GREECE_FORESTRY/MapServer), which is circled in red. Other sections include 'Browse Graphic', 'Keyword', 'Geographic', 'Temporal', 'Conformity', 'Constraints', 'Organisation', and 'Metadata Reference Information'.



Figure 4: UP: Details of a web page of a resource in the IMS/FORTH INSPIRE Geoportal. BELOW: The IMS/FORTH INSPIRE Geoportal Search functionality.

## 6. Conclusions

A number of geospatial tools have been used for olive oil mills' wastes (OOMW) disposal areas management, manifesting the potential of the particular technologies in an environmental issue which is of crucial importance especially in the Mediterranean area. Among the various techniques used, a freely distributed soil monitoring system application tool has been developed for monitoring several soil physico-chemical parameters which reflect the wastes' disposal activity. The particular application is based on a regular analysis of the soil physico-chemical parameters and it can be used either from individual owners or by larger administration units. A much more specialised application was made for monitoring the distribution of different soil parameters (in terms of depth and time) that represent their possible diffusion and the degree of risk in the vicinity of the waste disposal areas. The particular module has made use of the Google Earth API so that the particular results can be projected on the available topographic and satellite images provided by Google Earth.

In terms of the geophysical approaches, the ERT preliminary results signified that this geophysical method could be a modern alternative of mapping the environmental pollution in OOMW areas, providing effective solutions to address such environmental problems. Future actions of this initiative will include the application of controlled ERT experiments in non-metallic tank simulating the real conditions of an OOMW and the geophysical modelling results could be complemented with flow modelling codes (employing stochastic models that calculate the pollutant diffusion).

Finally, all the GIS based cartographic products of the project PROSODOL together with their accompanied metadata were made available to the public through the development of IMS/FORTH INSPIRE Geoportal, confronting the results of the project with the European Union INSPIRE Directive.

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