

Toxicological database of soil and derived products (BDT)

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Summary. The Toxicological database of soil and derived products is a project firstly proposed by the Regional Environmental Authority of Apulia. Such a project aims to provide comprehensive and updated information on the regional environmental characteristics, on the pollution state of the regional soil, on the main pollutants and on the reclaim techniques to be used in case of both non-point (agricultural activities) and point (industrial activities) sources of pollution. The project's focus is on the soil pollution because of the fundamental role played by the soil in supporting the biological cycle. Furthermore, the reasons for the project are related both to the reduction of human health risks due to toxic substances ingestion (these substances are present in some ring of the eating chain), and to the recognition of the importance of the groundwater quality safety (primary source of fresh water in many Mediterranean Regions). The essential requirements of a data entry are the following: speed and simplicity of the data entry; reliability and stability of the database structures; speed, easiness and pliability of the queries. Free consultation of the database represents one of the most remarkable advantages coming from the use of an "open" system.

Key words: toxicological database, soil pollutant, geographical information system, intervention techniques.

Riassunto (*La banca dati tossicologica del suolo e dei prodotti derivati (BDT)*). La banca dati tossicologica del suolo e dei prodotti derivati (BDT) è un'iniziativa dell'Assessorato all'Ecologia della Regione Puglia, creata per fornire informazioni complete e aggiornate sullo stato di inquinamento del suolo pugliese. Il suolo svolge un ruolo essenziale nel ciclo biologico e pertanto diventa necessario prevenire i rischi di avvelenamento umano, derivanti dall'assimilazione di prodotti tossici o contaminati, attraverso la catena alimentare, e salvaguardare le risorse idriche sotterranee, sempre più compromesse. Il portale verticale BDT con i suoi servizi (banca dati dei principali inquinanti del suolo, archivio cartografico del territorio pugliese, dati analitici relativi ai suoli, banca dati delle tecniche di bonifica, sistema informativo ed anagrafe dei siti potenzialmente contaminati) è consultabile liberamente via Internet alla sezione dedicata del portale ambientale del sito istituzionale della Regione. La banca dati tossicologica del suolo e dei prodotti derivati rappresenta un utile strumento di prevenzione dell'inquinamento del suolo, di sostegno alla pianificazione territoriale e di monitoraggio dello stato dell'ambiente.

Parole chiave: banca dati tossicologica, inquinanti del suolo, sistema informativo geografico, tecniche di bonifica.

INTRODUCTION

The growth of toxicological expertise and the demands of controlling the toxic dangers continue at a fast pace. A higher number of operators need to have at their disposal toxicological reports concerning products and chemical substances used in agriculture or contained and released in waste. These reports should include metabolic data and information concerning the fate of these substances (dispersion in the environment, permanence in the ground, degradation). This work hence includes a data bank in paper form, edited also on CD and easy to consult on the Internet, of the toxicological substances found in the land of Puglia and that for any reason may exist in the ground. It has been chosen to focus the attention on toxic pollutants of the soil because of its primary role

as substrate in which the biological cycle occurs, the need to prevent human poisoning risks, deriving from the assimilation of toxic products of the alimentary chain and to safeguard subterranean water resources, every day increasingly endangered. The aim of this work is promoting the concept of safety by a better updating of available information on potential dangers that the operator, the worker and the customer of soil products may face.

This data bank cannot contain all the published data concerning the toxic substances of the ground, but the features of the data entry are able to allow the operator to have an easy access to all the substances that may be potential chemical pollutant of the soil, and at the same time to have access to a series of data that may have chemical, toxicological,

analytical and medical interest. An ideal system should be very close to a continuous papery report containing all the information. It has been done all the best, in order to avoid a forced path of input so to make possible for the customer an easy access to the entire program. This sort of planning out supports the direct examination of the data avoiding potentially easy mistakes and time consuming.

For these reasons, integrated analysis has been performed aiming to gather information about:

- the soil quality;
- the pollutant matters;
- the risks for the population health and for the other environmental resources quality (mainly ground-water);
- the priority degree for the de-contamination actions;
- the intervention strategy and techniques.

The main outcomes of the project is a database containing information on soil pollution issue. The database is available on the internet in the Regional Environmental Authority website. Therefore, the information is easily consultable along with other important information like Cartographic Archive of the regional territory and Reclaim Techniques Database. More in detail, the involved organizations are:

- Regional Environmental Management Authority of Apulia;
- Regional Environmental Protection Agency of Apulia, dealing with environmental resources management and safety;
- Water Research Institute – Italian National Research Council, dealing with the rational utilization and protection of Italian water resources;
- University of Bari, involving Departments of medicine, Agro-Forestry and Environmental Chemistry and Biology, Plants Protection and Microbiology;
- University of Lecce, involving the Department of Innovation Engineering.

THE AIMS OF THE BDT PROJECT

As stated previously, the general aim of the project concern the implementation of a database, composed by many sections, providing easily consultable, rigorous, and updated information on regional environment, on the soil pollution state, on the most diffused toxicological substances and on the reclaim techniques.

To reach this general aim, many specific aims have been defined for this project:

- the definition of 600 toxicological cards of the chemical substances used in the agriculture (pesticides, manures, compost, etc.) or derived from industrial discharges, from rubbish dumps and other pollution source;
- the definition of a regional map with the spatial identification of contaminated sites using remote sensing technologies;
- on site analysis regarding the main pollutants;

- the validation of the on site analysis' results verifying them by an integrated analysis in all the laboratories involved in this project;
- the evaluation of chemical-physical degradation processes of some pesticides used in the agriculture;
- the implementation of a toxicological database (Database Management System) as a tool to support environmental safety interventions (reclaim of contaminated sites, control and inhibition of risk situations, definition of regional norms on environmental safety). In DBS, also information on the most efficacious reclaim techniques according to the kind of degradation is stored;
- the definition of an interface between the Database Management System and a Geographical Information System (GIS) with the aim to optimise the integrated management of the information both spatial (thematic map *Figure 1*, satellite images, etc.) and alphanumeric (chemical analysis results, reclaim techniques, etc.);



Fig. 1 | Example of thematic maps.

- the definition of a database of the reclaim intervention procedures for the most diffused human activities on the regional territory;
- the diffusion of results;
- the training of public officials with particular emphasis on the information system management and on the use of the databases.

THE IMPLEMENTATION PHASES OF THE BDT PROJECT

The project's aims were achieved in two distinct phases; each of those is characterized by many sub-steps, as described following:

First part

- phase A: definition of the toxicological cards. These cards describe the physical, chemical and toxicological characteristics and the environmental fate of the substances used in agriculture or contained in the wastes poured on the regional territory. Furthermore, they provide information on reclaim techniques for each substance;
- phase B: definition of homogeneous areas of the regional territory according to the degree of pollution risk due to both non-point source of pollution and contaminated sites. In this phase, many thematic maps have been drawn allowing us to create a holistic picture of our environmental state. This knowledge layer contributes to define the potential degree of soil pollution and to assess the groundwater intrinsic vulnerability due to pollutants on the soil;
- phase C: Information System implementation. All the graphical and alphanumeric data are stored in an information system. The information can be retrieved from the system using the web technology;
- phase D: chemical, physical and pedological analysis of the area with a high degree of pollution risk. A preliminary step to this phase concerns the identification both of the potentially pollutant cultivations due to the chemical products used, and of the main industrial areas. The analysis on the soil samples have been performed according to the Italian norms. These analysis aim to the chemical-physical characterization of the soil and to determine the pollutant quantity in the soil (pesticides, heavy metal, EOX, IPA);
- phase E: definition of homogenous areas according to the degree of pollution risk. The assessment of the main pollutants' chemical-physical characteristics allows us to identify the areas with a high degree of environmental risks. Statistical analysis methodologies (*e.g.*, cluster analysis, etc.) and risk assessment methodologies have been used to define a decision support tool able to suggest strategies to reduce environmental pollution risk;
- phase F: definition of the contaminated sites reclaim techniques. This phase is focused on providing information about both the analysis procedures, the reclaim methodologies and administrative issues regarding the contaminated

sites on the regional territory. The definition of the reclaim methodologies has been carried out considering both the criteria suggested by the National Energy and Environmental Agency (ENEA) and the agro-biological technologies for the pollution due to the agriculture;

- phase G: information system management. To manage the database of the project, a shared information system has been developed. Many management phases are defined to maintain and to update the database. Moreover, a training phase is carried out focused on end users supporting them in using and managing information system.

Second part

- action 1: verification of information system performances. This phase aims to verify the performances of the system according to end users judgment. In this phase, the end users' suggestions have been gathered to optimise both the geographical and alpha-numeric data consultation and management;
- action 2: integration of geographical information system data. Many data have been added to the information system during this phase. Thus, the system is conceived as an "open system", easily upgradeable, able to deal with environmental data coming from a monitoring system;
- action 3: data transfer. In this phase many efforts have been made to facilitate the transfer of the data to the end users and to the community. More in detail, these efforts comprise informational seminars, demonstration activities and technical support for the information system management.

THE RESULTS OF BDT PROJECT

The BDT project produced many results, all of them focused to resolve different environmental problems. More in detail, the main results are:

- The development of a database concerning the soil pollutants. This database is composed by more than 600 cards containing information on the chemical, physical and toxicological characteristics of the main pollutant substances. The database information could be useful to support following activities:
 - to define a priority degree for the reclaim intervention of contaminated sites;
 - to define emergencies interventions in case of environmental risk;
 - to support the hospitals in diagnosis formulation in case of poisoning due to toxicological substances. In this case into the hospitals can directly consult the database retrieving the needed information on the substances;
 - to support scientific community involved in researches dealing with pollutant substances.
- The development of the regional cartographic database. Such a database, containing all the thematic map of regional territory, is able to support the actions of spatial planning allowing:

- the localization of areas characterized by particular environmental features or by natural and human induced phenomenon;
- the creation of an holistic cognitive picture of the regional territory;
- the definition of a priority degree for the intervention;
- the management of a great amount of geographical data;
- the definition of the techniques and methodologies to be used in the reclaim of contaminated sites;
- the localizations of the most adequate areas for particular human activities according to their natural characteristics;
- the identification of the most pollutant human activities allowing the decision makers to define constraints for these activities according to the surrounding environment's characteristics.
- The development of an information system. The information system has been defined to facilitate the access to the information contained in the database and to support the end users in the definition of the environmental priority, in the formulation of alternative courses of action and in the evaluation of technical and economical conveniences of each alternative.
- The availability of soil analytical data. It is extremely important to provide information on both non-point sources of pollution (mainly agriculture) and point source of pollution (mainly industrial discharge). More in detail, the availability of this data produced many positive results:
 - to obtain data on pollution concentration;
 - to lead the soil reclaim activities;
 - to lead the monitoring activities, involving more environmental components than the soil;
 - to define the efficacious planning strategies to reduce the impacts of agricultural activities;
 - to evaluate the environmental risk due to human activities;
 - to identify the variables describing pollution processes;
 - to provide data and information to be used in mathematical modelling of the pollutants' environmental fate.
- The development of the reclaim techniques' database. Using the information contained in the scientific literature regarding the reclaim techniques, a database of all these techniques has been developed. In this database the reclaim techniques have been related with the different environmental characteristics and the different pollutants characteristics. These information supports:
 - the identification of emergency interventions;
 - the definition of the surveying plans, preliminary to the intervention phase;
 - the comparison among the different intervention strategies;
 - the assessment of the efficaciousness of changes introduced during the intervention strategies implementation.

Furthermore, many side-effects have been reached with the implementation of this project. The main positive side-effects concern the wide diffusion of geographical information to the public because of the use of the web technologies. In fact, since the project's implementation, the consultation of cartographic and thematic maps was complex and uneasy. Currently, after project's implementation, any user can download different maps and use them to elaborate information different from the project's aims. Moreover, the BDT project's implementation contributes to the integration of different projects' results concerning other environmental issues at the regional scale, in an environmental integrated assessment perspective.

Summarizing, the outcomes of the project can be really useful in supporting several activities:

- the BDT outcomes can support land-use planning at regional scale;
- they facilitate the evaluation of the priority among different possible interventions (*e.g.*, reclaim interventions of contaminated sites);
- they constitute a shared knowledge-base that is continuously integrated and updated;
- they facilitate the access to the information, both graphical and alphanumeric, regarding the regional territory and the environmental state by using the information technology.

THE DEVELOPMENT OF A TOXICOLOGICAL DATABASE CONCERNING THE SOIL POLLUTANTS

The contamination of the soil by continuous pollution sources has direct and serious implications on the quality of the agro-alimentary products, on water resources and hence on human health. In order to identify the main pollutants of the soil, with particular attention to the very common ones in agriculture, pesticides registered in Italy have been carefully considered and an investigation of the principal contaminant activities has been conducted.

The selection of the substances has been carried out on the individualisation and analysis of:

- pesticides used and useable in Italy, with a specific reference to the usual ones for the soil;
- main toxic products, used and diffused because of different causes such production, entertainment;
- toxic substances in the temporary waste and in the authorized dumping.

In particular, for what concerns the selection of the pesticides, the official list of active compounds has been considered.

In order to identify further toxic substances, it has been considered that the soil is often the place where the authorized storage is, but also it has been considered that the ground is the place in which abusive dumping has place.

Moreover, all the industrial activities and procedures with all the starting materials, the final

products, secondary products and waste have been analyzed.

The result has been a study extended to 350 pesticides and other 250 pollutants, among which are listed inorganic compounds (metals and ions), and organic compounds as well (aliphatic hydrocarbons, aromatic hydrocarbons).

The elaboration of the toxicological report has been preceded by a wide bibliographic research on specialised textbook, handbook, NIOSH reports, INRS etc., hyper textual data bank. In particular, among the numerous data bank, the following have been consulted:

- TOXLINE, produced from NLM (Numerical Methods Laboratory), which is a database where 16 sub-archives exist, some of them are complete, some others exist as Biological Abstract, International Pharmaceutical Abstract and International Labour Office;
- TOXLIT, produced from American Chemical Society, considers the part of the Chemical Abstract concerning the toxic effect of drugs and chemical substances in men and environment;
- HSDB (Hazardous Substances Data Bank), produced from the NML about the Toxicology Information Program, containing information on 4200 potentially dangerous substances;
- RTECS (Registry of Toxic Effects of Chemical Substances) belonging to NIOSH, which analyses 120 000 substances with data on mutagenesis, carcinogenesis and teratogenesis reported;
- CCRIS (Chemical Carcinogenesis Research Information System) of the National Cancer Institute gathering complete bibliographic references published on literature since 1976 about carcinogenesis tests tumour promoting and inhibition factors, evaluated according to the criteria of experts;
- IRIS (Integrated Risk Information System) of the EPA analyses the risk caused by exposition to chemical substances;
- GENETOX (Genetic Toxicology) of the EPA gives the information about mutagenesis of 4000 substances;
- EMICBACK (Environmental Mutagen Information Centre Back-file) of Oak Ridge National Laboratory that considers the chemical, physical and biological products analysed in order to estimate their genotoxic activity;
- other lists produced by EPA with information on dangerous substances release in the environment (Toxic Release Inventory and its back-files).

This study was to elaborate toxicological reports on polluting substances of the soil, in order to represent a complete guide for analytical determination and a valid help for technicians and specialised operator involved in the study about the risks of the environment and human health. In order to facilitate the study's contents consultation, both in this present hard copy as well as in the virtual database, a file-cards architecture has been defined which organises in well defined sections all the information,

related to the possible utilizations: scientific, land and environment supporting, diagnostic and therapeutic, agricultural etc.

The need of having chemical-toxicological file-cards comes from analytical chemistry and toxicological laboratories, where the chemist needs to have a comfortable and complete guide as a reference during his investigations into any materials. The difficulties during the "unknown" analytical research on samples containing potentially toxic substances are:

- the large number of the potentially toxic compounds for man;
- the limited time for analysing the samples, sometimes under pressure (*e.g.* after an environmental disaster);
- non sufficient available data related to the particular toxicological case;
- the possibility of facing analytical methodologies never used previously by the operator;
- the potential concomitant presence of two or more pollutants at the same time and the possibility of interaction among these substances.

The necessity of having toxicological file-cards, including data concerning the behaviour of the substances (degradation, environmental fate), is now felt more and more urgent, and so the possibility of access to this sort of information will produce a sure decrement of the toxicological risk for the whole population.

The publication and the availability of the Toxicological Data on the Internet will allow the authorities for the environmental surveillance and control (Regions, Provinces, Local Health Authorities, Civil Protection, ANPA etc.) to operate immediate and accurate interventions in order to safeguard the environment.

THE INNOVATION OF BDT PROJECT

The BDT project is characterized by different innovative elements:

The wide involvement of actors operating in different fields like the environmental safety, the public health, the spatial planning, etc., with the aim to create a collaborative and synergic environment to solve problem at regional scale.

The new organizational structure strongly web-based. This structure facilitates the information exchange and the integration among the different operative units geographically dispersed. All the documents have been elaborated by different authors and they are stored in virtual "showcases" to be available for all the participants. Many video-conferences have been carried out and the database have been developed simultaneously from different workstation connected by the net.

The use of the web facilitates, further, the result's diffusion and their accessibility to the public.

The promotion of active partnerships involving different organizational units. During the project implementation many organizations, further than those al-

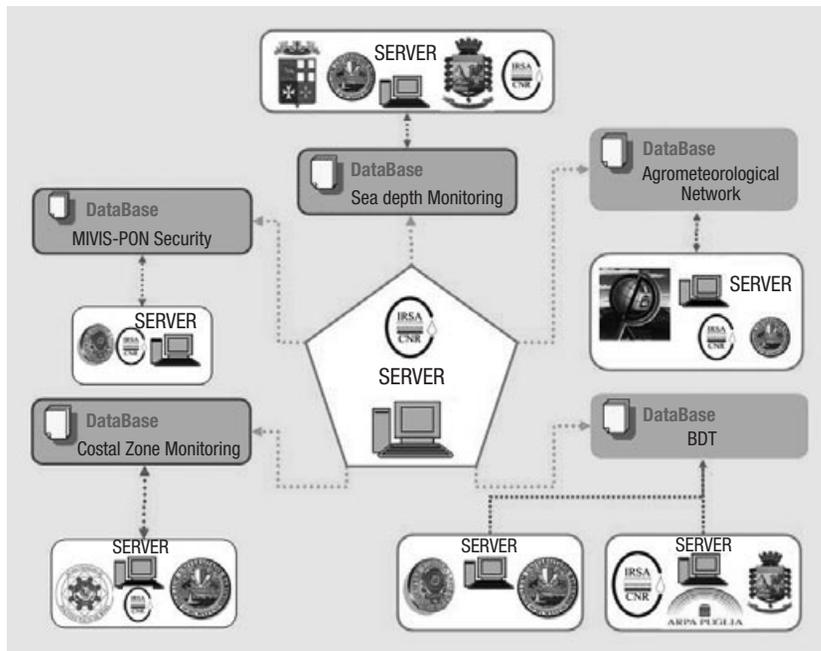


Fig. 2 | Integration with other projects.

ready involved, actively participated providing useful information and knowledge in a participative planning prospective.

THE MAIN DEVELOPMENTS OF THE BDT PROJECT

The main elements contributing to the success of the project are the integration (Figure 2) and the coordination.

The integration is a fundamental element to create synergies among different initiatives and projects in the environmental safety, valuing the strength points and reducing the weaknesses. In this perspective, the BDT project could lead to the integration among different environmental safety initiatives at regional scale:

- Contaminated sites monitoring activities: this project is currently carrying on by Water Research Institute in collaboration with Regional Environmental Protection Agency and with our Police. This project aims to identify the contaminated sites already present in the regional area and to characterized them in order to define the intervention priority at regional scale. The implementation of this project is leading to various positive effects. Firstly, a deeper environmental sensitivity is emerging in the local administrations. Furthermore, the continuous control of the territory is leading to a reduction of the number of environmental crimes. This project is strongly related with BDT project. In fact, the information coming from this continuous monitoring activity can be used to update the database of the BDT project.
- Contaminated sites characterization: all the outcomes of previous project aiming to analyse the

contaminated sites, both at national and regional level, will be included in the BDT database.

- Soil Remediation Archive: the data and the information concerning the reclaim activities already implemented in the regional area will be inserted in the BDT database. Moreover, a monitoring activity will start aiming to verify the efficacy of the adopted techniques according to the pollutants and to the environmental characteristics.
- Epidemiological observatory: the information regarding the toxicological substances, stored in the BDT project, will be compared with the epidemiological data with the aim to discovery the interactions among the environment and the human health.
- Regional Environmental Information System (SIPA): all the map realized in the BDT project will be stored also in the SIPA.
- Agro-meteorological net widening (ARA): there is a strong interaction between this project and the BDT. In fact, on one hand the cartographic information developed in the BDT project will be available for the ARA project. On the other hand, during the implementation of the ARA project a lot of data will be obtained by a monitoring system concerning the irrigation water and the soil. These data will be used in BDT project to define Best Agricultural Practices that will be diffused among the farmers.

The coordination plays an important role in complex studies, highly multidisciplinary, to lead all the efforts towards a common goal. In BDT project, the coordination among all the involved actors guarantees the collaboration and favors the labor division according to the previous experiences and the scientific knowledge of all participants.

THE TRANSFERABILITY OF THE PROJECT

The project's transferability mainly regards the methodology for non-point sources of pollution control, the development of environmental monitoring structures and the emphasis on the environmental planning to reduce the pollution risk.

A partnership with Hungarian Government is carrying on. The partnerships is built on the BDT project's experiences transfer with particular emphasis on:

- the improvement of control system for the pesticides and, in general, for the environmental quality;
- the focus on the sustainability of agricultural practices (non-point sources of pollution);
- the improvement of the monitoring system to support the environmental resources planning.

CONCLUSIONS

The BDT project could be considered as a best practices because it is having a positive impact on land planning and natural resources management. In fact, the implementation of the BDT project induced an increase of the available knowledge on the local

environment and on many phenomenons, both natural and provoked by the human activities, that could lead to the environmental pollution. This knowledge sharing can have a positive effect on decision-process at different levels. First of all, the available knowledge can be used by local decision-makers to improve the decision-making processes and to increase the effectiveness of the actions against environmental resources degradation. Furthermore, this knowledge can be accessed by the professionals which operate in the environmental resource analysis and management constituting an objective and common knowledge base and, thus, reducing the risk of subjectivity in environmental analysis. Finally, the knowledge can be accessed by the citizens making them more informed on the environmental safety issues and suggesting them how to avoid pollution risk and how to act in order to reduce such a risk. Thus, sharing this knowledge a deeper public sensibility toward the local environment safety could appear.

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