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## ANALYSIS OF INFORMATION SUPPORT FOR THE CONDITION OF SOIL RESOURCES IN UKRAINE

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The contemporary condition of soil cover in Ukraine is characterized. The attention is focused onto widespread degradation processes in soils. The causes that determine the development of these negative processes are considered. The contemporary informational support for the condition of soil cover in Ukraine is estimated. In general, the current available information is of narrow-departmental nature, obtained by different methods and non-correlated monitoring programs. As a rule, it is stored in under-structured databases, incompatible with other information systems; mainly recorded on paper media unusable with modern technologies, whereby such information resources are difficult to be compiled together. These disadvantages are strong constraints against consistent usage of materials for evaluation, forecast and management of changes in the soil cover. The Soil Observation program should thereby be combined with Agrochemical Passportization and ecology-ameliorative monitoring; in other words, the application of innovative soil-agrochemical methodology is considered. Each individual type of surveys shall complement the others, and taken altogether, they shall constitute a consistent Information System, capable of solving the problems of assessing the condition, forecasting, management, usage and protection of soil resources. The monitoring procedures should be conducted on the basis of a new soil concept in line with unified programs and methods, so as to meet European approaches to the maximum extent. Such a technical composition enables getting information on present-day processes in soils, and is the only combination that actually helps us to "ecologize" our knowledge of soils, which is the leading trend in the scope of global soil-science. Thus obtained results will serve as a State-owned tool which would subsequently facilitate the use and protection of soil resources all over the country, to be involved in a united global soil-information scope. The attention is focused onto social significance of the information on soils and their fertility in terms of land resources optimization, as well as the formation of sustainable land use in Ukraine.

**Key words:** soil cover, soil fertility, soil degradation, soil protection, agrochemical observation, information system.

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Soil is the main irreplaceable natural resource, determining the stability of life on the Earth, however, human impact on soil resources reaches critical limits. Many countries of the world have reached their understanding on the state level regarding the necessity of taking urgent whole-planet measures to prevent global ecologic crisis which is the consequence of destruction, pollution, and degradation of soils. This fact is confirmed by the decision of the United Nations Conferences on Environment Protection in Stockholm (1972) and Rome

(1981) where the World Soil Charter was endorsed under the auspices of FAO; Rio de Janeiro (1992) and Johannesburg (2002) [1] where over 200 countries, including Ukraine, elaborated and pledged to implement the Concept of Sustainable Development regarding soils – the method of land use management, providing for the needs of contemporaries with no harm to future generations. In 2012 in Rio de Janeiro the United Nations Rio + 20 Conference confirmed the commitment to the Agenda 21 and the purpose, endorsed at the

World Summit for Sustainable Development in 2002. FAO Committee on Agriculture played a decisive role in the elaboration of the Global Soil Partnership (GSP) at the end of 2012. Prior to this event, there has been no international authority, presenting soil issue in the global dialogue and in the decision-making processes. This initiative of FAO, due to the global mandate of this organization, is focused on the consolidation of efforts of all the people and organizations, interested in preserving the soil as it is a limited natural resource. The second session of the Plenary Assembly of GSP finalized the text of the World Soil Charter, the process of endorsing which will involve its consideration on the 39<sup>th</sup> session of the FAO Conference (June 6–13, 2015). The authors deem it necessary to substantiate the update of the Charter text as follows: *“There is an urgent need to update the vision and guiding principles as spelled out some 30 years ago by FAO Member Countries in the World Soil Charter (FAO, 1981). The 13 principles listed in the charter are still valid, but need to be updated and revised in light of new scientific knowledge gained over the past 30 years, especially with respect to new issues that emerged or were exacerbated during the last decades, like soil pollution and its consequences for the environment, climate change adaptation and mitigation and urban sprawl impacts on soil availability and functions. New priorities for action as well as follow-up activities should be identified, taking stock of past experiences and learning from the failures and mistakes that have resulted in a still persistent global problem of soil degradation and unsustainable use of available soil resources.”* [2].

The ecologic policy of the European Community is also based on the global purpose of sustainable development [3]. One of the goals of the Sixth Community Environment Action Program is the protection of soils from pollution, erosion, desertification and degradation. The Thematic Strategy on the protection of soil (the Strategy) was adopted by the European Commission on September 22, 2006 [4]. The main principle of the Strategy is prevention of problems and implementation of the prevention principle, since soil is a limited resource, suffering from the negative impact in the environment. Five years after the adoption of the Strategy, on February 13, 2012, the European Commission published a policy report on the implementation of the Strategy and ongoing activities. The report provides an overview of the actions undertaken by the European Commission to implement the four pillars of the Strategy, namely awareness raising, research, integration, and legislation. The Strategy has acted as an important

driver for numerous soil awareness raising tools and networks that have been developed in Member States, including the European Network for Soil Awareness (ENSA). Raising awareness about soil presents a particular challenge, because knowledge about the status and quality of soils remains fragmented. Therefore, the world has deeper understanding of the relevance of soils, their contribution into the economic growth, biodiversity, sustainable agriculture and food safety, poverty eradication, solving the problem of climate change and improving the access to water.

The ecologic leverage is gradually introduced into different sectors of Ukrainian economy, but even now the economic, administrative, financial and other branches of legislation are not completely intervened with the ecologic, soil-protection legislation. Due to this fact and taking into account the optimization of the soil resources of Ukraine it is especially urgent to ensure the information support for the condition of the soil cover, considering the dynamics of the changes in soil properties.

Soil resources are a strategic resource, the prerequisite of the country's security. However, modern state of the Ukrainian soil cover raises concerns due to anthropogenically caused changes in its condition and wide spreading of degradation processes: the areas of degraded and low-yield land are in the range of 5–6 to 10–12 million hectares [5]. Among the reasons, determining the contemporary condition of soils, noteworthy are uneven and extremely intensive agricultural use of territories on condition of a considerable area, the use of which is legally restricted, and the shortage of land, intended for nature protection purposes, ambiguity of significant area of degraded land, *etc.* [5]. One of the main reasons of soil degradation in Ukraine is insufficient level of state management of soil resources, especially in the sphere of soil protection, their rational use, resulting in the absence of sufficient information system for the condition of the soil cover [6].

Nowadays the agrarian sector faces an urgent need to update the approaches and available materials of informational support, which is conditioned by the registration of soil and land resources, the requirements of the State Land Inventory, the implementation of land surveying work and projects, the formation of the land market, land assessment and evaluation work, the introduction of adaptive landscape systems of agriculture and market mechanisms in the agrosphere. The above-mentioned proves the relevance of detailed and precise information about the condition of the soil cover as the basis of state land policy.

At present there are the following sources of information about the soils and soil cover: materials of large scale soil survey; land inventory; materials of agrochemical passportization of the land intended for agricultural use; materials of ecologic and ameliorative monitoring; the data of scientific institutions, higher educational institutions; the data of the state system of land monitoring, *etc.*

#### **The materials of large scale soil survey (1957–1961)**

The survey was conducted under the scientific and methodological leadership of the Ukrainian Scientific Research Institute for Soil Science named after O. N. Sokolovsky (currently – NSC “Institute for Soil Science and Agricultural Chemistry named after O. N. Sokolovsky”), the results were further (25 years later) partially corrected by the Ukrzemproject, but due to their use of outdated normative and methodological support, it did not promote the increase in the informative value of the soil materials [7]. At present these materials reflect the actual state of the soil cover approximately for 30–50 % [7], thus it is relevant to update and improve them, which requires another large scale soil survey.

Due to this fact the draft Concept and State program of large scale soil survey has been prepared which will allow obtaining the following results:

- current reliable information about the soil resources of Ukraine, improved zoning of the land and natural and agricultural breakout of Ukraine into districts, the parametric data of soil surveys as the basis of the formation and functioning of the state soil policy, civilized land market and land relations, the solution to food, ecologic and social problems;

- the set of modern map data, the reference and inquiry system (database), required to select the directions and perspectives of ecologic and economic development of territories, to solve the problems of land use and the creation of erosion-free land use on the slope territories;

- maintenance of stable agriculture, optimal ratio of agriculturally used lands, the introduction of adaptive landscape systems of agriculture, resource-efficient agrotechnologies, the refinement of especially valuable land, the determination of soil suitability quality of soils as the basis of the organization of efficient agriculture and the characterization of agroinvesting attraction of the territories;

- scientifically justified recommendations for each household (land user), the justification of the systems and technologies of the utilization of fertilizers and

- chemical ameliorants, the increase in the yield of agricultural crops by 5–10 %, the provision for the food safety of the state;

- the implementation of land surveying, land assessment and monitoring work, the elaboration of the land survey projects and ecologically justified crop rotations, land conservation of degraded, technologically polluted land, and lands of low productivity, agrochemical passportization of land, intended for agricultural use;

- improved database of legal and regulatory and methodological documents on the issues of rational use and protection of lands, preservation and restoration of soil fertility.

#### **State land inventory**

The state land inventory is based on the data of the large scale soil survey of 1957–1961. According to the Order of conducting the State land inventory, approved by the resolution of the Cabinet of Ministers of Ukraine, the update of the information on the land quality should be made once in five years. Unfortunately, this provision of the Order has not been implemented and at present there is no objective and comprehensive assessment of the soil quality as an object of land inventory.

#### **Agrochemical passportization of the land, intended for agricultural use**

The agrochemical passportization of arable land is conducted every five years (according to the Order of agrochemical passportization of fields, land plots), approved by the Ministry of Agrarian Policy and Food of Ukraine No. 536, dated 11.10.2011). Since 1965 [8] there have been nine rounds of the agrochemical passportization with the issuance of agrochemical passports to land plots. The materials obtained were summarized in the form of the National Report on the status of soil fertility (2010) which should be used while compiling the State land inventory, in the land survey projects, in the process of regulating the land relations while transferring the land into someone's ownership, on lease, *etc.*

However, the overall agrochemical passportization has its drawbacks, in particular, there are mixed soil samples in the process of field traverse without any connection to the geographic reference system, insufficient set of controlled indices, non-conformance of the lands in the rounds, failure to take the spatial ambiguity into account, which complicates the use of this information for soil monitoring. It is important to improve

the method of agrochemical passportization in accordance with unified programs and methods, adapted to the requirements of EU. We suggest conducting a new kind of soil surveying – soil-agrochemical survey – that is soil surveys should be conducted along with agrochemical passportization.

**The information on the ameliorative condition of the irrigated and drained lands** is obtained while conducting the ecologic and ameliorative monitoring (EMM) of irrigated and drained lands (in accordance with the Instruction on organization and monitoring of irrigated and drained lands, approved by the State Water Resources Agency of Ukraine No. 108, dated 16.04.2008.). The subsidiaries of the State Water Resources Agency of Ukraine have been performing this work since 1964. The information, obtained due to the systematic control, is current, reliable and up-to-date. Still, EMM has its own drawbacks: the area under control is only about 6 million ha, and a limited set of indices is taken into account: in irrigation conditions – mineralization and chemical composition of subsurface and irrigation waters, irrigation water quality, the level of subsurface waters, drainage flow, soil salination and alkalinity; in draining conditions – the level of subsurface waters, the chemical composition of subsurface and surface waters, the acidity and humidity of soils. These indices are used to prepare field reports on the condition of irrigated and drained lands and to assess their ecologic and ameliorative condition. In our opinion this kind of field monitoring should be included into the unified system of state environment monitoring to complete the materials of soil-agrochemical surveys, and to be combined with the materials of agrochemical passportization.

**The data of scientific institutions, higher educational establishments** (field experiments, practice grounds, routing surveys, permanent plots and permanent monitoring observations). NSC “Institute for Soil Science and Agricultural Chemistry” has elaborated the unique database of the relational type “Soil Properties of Ukraine” [9] which covers the observations for the soil properties since the 1960s and contains the data about over 2,000 cuts with the full set of indices (about 250 indices of the composition and properties of soils) with accurate reference in the geographic reference system and software that can be used in the analytic and mapping work. It was used as a basis to create the information system, related to the international information system [10]. Long-term studies of the condition and changes of the properties of the Ukrainian soils,

involving control over a considerable number of soil indices allowed the scientists to prepare and issue the National Atlas of Ukraine and the Soil Atlas of Europe (section: Ukraine) [11].

NAAS has been conducting the monitoring in the network of long-term field experiments. The inventory of the latter has been composed, including 97 experiments. Some experiments in the inventory are unique in their duration (about 100 years) and its content, some of them have been included into EURO-SOMNET, the European system of experiments. The experiment status, the forms of the passport and certificate of NSC “Institute for Soil Science and Agricultural Chemistry” [12] have been elaborated and approved; the software “The information system. Permanent field experiments” has been elaborated and transferred to the scientific research institutes and higher educational establishments as it was intended for the formation of the database of the experimental information for the whole period of the experiment. It allows accumulating and quickly processing the information obtained using modern statistical methods.

The improvement of the observations in permanent field experiments requires the inventory of field experiments, ranging of experiments into two levels – state and regional ones – with the relevant financing; reconstructing field experiments, supplying them with lysimeter stations, experimental watersheds, conducting new experiments according to the approved schemes with the consideration of the soil diversity, creating and filling in the database and the information system regarding the long-term field experiments according to the international requirements; introducing the periodic issue of the bulletin with complete information about the results of experiments; reviewing the composition of the scientific and methodological commission, determining the directions of work and their implementation (to organize the experiments).

**Soil monitoring in the framework of the State Environment Monitoring System.** Soil monitoring is defined by a number of legal and regulatory documents [1], but it has not been organized and financed in a proper way. Besides, there is no stipulated unification of the methodology and coordination of the rules of monitoring, as well as improvement of the current monitoring networks, subordinate to the subjects of the monitoring system, and the elaboration of the unified state monitoring system (monitoring stations) [1]. All this complicates the elaboration of the unified state monitoring system and does not allow using the bulk

of the current information, assessing and predicting the condition of soil resources to the full extent. At present soil monitoring is actually performed by the Ministry of Agrarian Policy and Food of Ukraine and the State Water Resources Agency of Ukraine. Some indices of the condition of soil resources are determined by other ministries and departments, responsible for a specific category of soils: the State Forest Resources Agency of Ukraine; the Ministry of Ecology and Natural Resources of Ukraine; the Ministry of Health of Ukraine; the State Hydrometeorological Service of Ukraine.

Therefore, due to the absence of the unified program and method of work, the incompatibility of the methods of determining indices, insufficient management of the department network and the presence of a number of other drawbacks, the insufficient soil monitoring in this country should be replaced with the state ecologic monitoring network with coordinated, unified control of all the environment components – soils, waters, air, soil waters, plants, natural resources, *etc.*

The issues, related to the elaboration of the set of measures to improve the environment monitoring and state regulation in the sphere of waste management, were considered at the meeting of the Ukraine's National Security and Defense Council on April 25, 2013. The resolution of this Council was approved by the Decree of the President of Ukraine No. 572/2013 dated October 18, 2013, which highlighted the absence of an actual state environment monitoring system in Ukraine, the work of the Ministry of Ecology and Natural Resources of Ukraine regarding the organizational integration of the subjects of the state environment monitoring system, the meteorological and metrological support for the integration of its constituents and components was found insufficient; it was suggested that the Cabinet of Ministers of Ukraine should elaborate and take measures regarding the efficiency enhancement of the activity of the state monitoring system, create and have approved the Concept of reforming the state environment monitoring system with the participation of the National Academy of Sciences of Ukraine, the National Academy of Agrarian Sciences of Ukraine, the National Academy of Medical Sciences of Ukraine.

At the same time the monitoring of soil resources in Ukraine should be approximated to the European requirements and is subject to modernization, in particular, the improvement of methodological foundations, which should be solved simultaneously with the update

of software, mathematical, mapping, and instrumental support [1].

The most urgent contemporary tasks are as follows [1]: revision, correction and digitizing of soil mapping materials on the basis of international nomenclature of FAO and WRB; coordination of current methodological approaches, programmes and methods with the European ones; elaboration of informational support for the soil monitoring to create an accessible informational database “Soil Resources of Ukraine” as a part of the overall system ecological monitoring; elaboration of remote means of soil resources monitoring – remote probing, aerial survey, *etc.*; improvement of current devices and elaboration of new means of monitoring. The final result of monitoring should be mapping-analytic materials about the current condition of soils, the automated informational system, the forecast of the condition of soils in time and technical and economic justification of urgent and long-term methods of soil protection. These materials may be used as a basis for the fastest and most reliable formation of the appropriate surveying and analytic informational system regarding the contemporary state of the soil cover.

A great number of legal and regulatory acts should be passed in order to improve the State soil monitoring.

At present the legal and methodological support for soil survey and monitoring has been elaborated. The functions of elaboration, expertise and approval of legal documents of different levels (DSTU, DSTU ISO, DSTU EN, SUC, TOR) in the sphere of soil science, agrochemistry and soil protection have been vested with the Technical standardization committee (TC 142) “Soil Science” which was established following the order of the State Committee for Standardization of Ukraine No. 480 dated September 26, 2001 with the approval of the Ministry of Agrarian Policy of Ukraine. The exercise of the functions of the front office of TC 142 has been vested with the National Scientific Center “Institute of Soil Science and Agrochemistry named after O. N. Sokolovsky”. During the years of activity (2001–2014) TC 142 “Soil Science” has elaborated 309 regulatory documents, including 132 national standards of Ukraine (DSTU), 160 national standards, coordinated with the international and European ones (DSTU ISO, DSTU EN, DSTU CEN), and 17 Standards of Ukrainian Companies (SUC) [14]. About 20–30 regulatory documents on the issue of soil survey, monitoring, agrochemical passportization of soils, including technical regulations on these issues, should be elaborated and implemented in the nearest future.

The scientific and staffing support for the development of the state system of informational support for the condition and rational utilization of soil resources of Ukraine implies the preservation of scientific potential, their advanced training, the introduction of specialists' onsite training in similar services of other countries, training of soil scientists for soil monitoring.

During the 23-rd session, which took place on May 21–25, 2012 the FAO Committee on Agriculture approved the initiative of creating the Global Soil Partnership. The first plenary assembly of GSP took place on June 11–12, 2013 in the FAO headquarters in Rome. Being the FAO member, Ukraine entered GSP since the moment of its creation.

In March 2014 the National Scientific Center “Institute for Soil Science and Agricultural Chemistry named after O. N. Sokolovsky” was the first to be registered as GSP partner in Ukraine. The purpose of the partnership was to support the joint efforts in developing stable models of soil resources management, which correspond to the criteria of food safety and are capable of withstanding negative impact of global climate changes. GSP interacts with scientific research organizations, thus ensuring the use of knowledge and studies to obtain actual results on-site. It is the quality of information about soils, the possibility of urgent access to it, complete awareness of the community and government about this information that GSP considers to be the prerequisites of elaborating the functional principles of stable land use and ecosystem management. The establishment of the unified informational resource regarding the soils of the country taking into account the experience of the international cooperation will promote the elaboration of timely, targeted, efficient and safe measures in the management of soil resources to protect them from degradation and to ensure the preservation of their performance.

Therefore, there is an urgent need to update the materials of the condition of the soil resources of Ukraine, using computer-aided mapping [9], GIS-technologies [7, 15], and to create the national informational soil-survey database [7], to form the unified informational resource regarding the soils of the country [6], *i. e.* it comes to the creation of the state system of informational support for the condition and rational use of the soils of Ukraine. The integration of the materials of soil survey, agrochemical passportization, ecologic-ameliorative monitoring,

soil monitoring will allow creating the unique informational and analytic database about the soils of the country, open for further extension and amendment with the consideration of level-wise distribution of tasks in a short period of time.

## CONCLUSIONS

Current sources of information about soils and the soil cover of Ukraine do not allow creating an actual, complete and reliable informational system regarding the modern condition of the soil cover. It is conditioned by the fact that the information obtained is mostly of department-level relevance, it has been received by different methods, using non-coordinated survey programs, most soil data are outdated, and as a rule, are located in non-structured databases, incompatible with other informational systems, being mostly on paper. It has been suggested to have the second large-scale survey of the soil cover of Ukraine, which will allow obtaining complete, spatially-referenced information about the actual condition of the soil cover of Ukraine, integrated with the agrochemical passportization; to create the state network of ecologic monitoring with coordinated, unified control of all the environment components, maximally approximated to the European requirements.

There is a growing understanding of the role of soils in ensuring food and ecologic safety of the Earth in the world. José Graziano da Silva, FAO Director – General emphasized, “We need healthy soils to achieve our food security and nutrition goals, to fight climate change and to ensure overall sustainable development”. That is why the UN General Assembly made its Resolution 68/232, dated December 20, 2013, to announce Year 2015 to be the International Soil Year, and December 5 – the World Soil Day.

Reliable, complete and accurate information in open structured databases is a crucial prerequisite of the implementation of new world soil policy. The soil protection policy of European countries is based on the information, obtained due to unified methods and approaches to the systematic monitoring of the soil cover. The systematic monitoring of soil is conducted by the EU members and some countries of Europe, which are not EU members. The monitoring is aimed at the creation of informational systems with reliable information, obtained due to the unified methodology of performing work in the extensive network of surveys [16]. The current European monitoring and

information system allows zoning the soils, determining their condition, revealing hot spots, developing the strategy of using the soil cover. Many European countries have exemplary informational systems of the condition of soil resources with complicated sub-systems (Germany, Austria, Sweden, the Netherlands, Belgium, *etc.*); there are unified informational databases, open to public access, with coordinated methods of work, based on modern methodological grounds (GIS, geopositioning, remote ways, referenced to on-ground surveys, *etc.*) with advanced information processing (prognostic models of soil processes have been created). It will allow Ukraine to form modern informational systems in a short period of time and to enter the European monitoring and information network.

#### Аналіз інформаційного забезпечення стану ґрунтових ресурсів України

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Охарактеризовано сучасний стан ґрунтового покриття України, акцентовано увагу на поширенні у ґрунтах деградаційних процесів, розкрито причини, які зумовлюють розвиток цих негативних процесів. Зроблено оцінку сучасного інформаційного забезпечення стану ґрунтового покриття України, яке не відображає реальності через розбіжності у результатах використаних інформаційних систем. Запропоновано заходи, які сприятимуть отриманню достатньої, достовірної, точної та оперативної інформації про стан ґрунтів, вирішенню проблеми охорони ґрунтів та підвищенню їхньої родючості. Ґрунтове обстеження має бути об'єднано з агрохімічною паспортизацією, еколого-меліоративним моніторингом, тобто мова йде про застосування нової ґрунтово-агрохімічної методики. Моніторинг має проводитися на новій ґрунтовій основі, за єдиними програмами і методиками і максимально відповідати європейським підходам. Отримані результати послугують державним інструментом, який дасть змогу врегулювати використання і охорону ґрунтових ресурсів країни та приєднатися до єдиного світового ґрунтового-інформаційного простору.

**Ключові слова:** ґрунтовий покрив, родючість ґрунту, деградація ґрунту, охорона ґрунтів, агрохімічне обстеження, інформаційна система.

#### Анализ информационного обеспечения состояния почвенных ресурсов Украины

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Охарактеризовано современное состояние почвенного покрова Украины, акцентировано внимание на распространении в почвах деградационных процессов, раскрыты причины, обуславливающие развитие этих негативных процессов. Сделана оценка современного информационного обеспечения состояния почвенного покрова Украины, не отражающего реальности из-за различий в результатах использованных информационных систем. Предложены меры, способствующие получению достаточной, достоверной, точной и оперативной информации о состоянии почв, решению проблемы охраны почв и повышению их плодородия. Почвенное обследование должно быть объединено с агрохимической паспортизацией, эколого-мелиоративным мониторингом, то есть речь идет о применении новой почвенно-агрохимической методики. Мониторинг должен проводиться на новой ґрунтовой основі, по єдиним програмам и методикам и максимально соответствовать европейским подходам. Полученные результаты послужат государственным инструментом, способным регулировать использование и охрану почвенных ресурсов страны и присоединиться к единому мировому почвенно-информационному пространству.

**Ключевые слова:** почвенный покров, плодородие почвы, деградация почвы, охрана почв, агрохимическое обследование, информационная система.

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