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SOIL DENSITY IS A FUNCTIONAL - GENETIC ASPECT

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Résumé. La monitorisation de la densité des sols spécifiques pour trois périodes, bien sur différentes pour chaque cycle annuel dans la densité et l`orientation des processus pédogénétiques. Les plus favorables conditions pour l`évolution des processus de tchernoziom sont crée pendant le printemps et au début de l`été ( Avril juin) ; l`humidité du sol est proche de la plus basse valeur en capacité d`humectation et les densités des sols sont 1,1-1,3 g/cm$^3$ .Pendant cette période la porosité totale a des valeurs de 55-56% et la porosité de l`aération est de 20-25% Cette période est caractérisée par la plus grande activité des processus biologiques avec les processus chimiques et physico-chimiques.

Modern condition, problems. In the soil science density of soil traditionally finds a use for the auxiliary purposes, and in particular for recalculation of mass dates of the contents in the soil of a moisture, humus, nutrients elements and others in volumetric meanings or for account general and differential pore space. In a number of works this parameter is used for an estimation of technological properties of soils (the hardness, specific resistance and others) **(**Revut, 1972**)** or with the purposes of an estimation of soil as environment for development of plants (Kachinski, 1965; Medvedev, 1979, 1980, 1984, 1988). The basic components of above -mentioned works are the description of interaction of soil density with other properties of soils, soil-hydrological constants, receipt in the soil and evaporation of a moisture, reaction of root systems and crops on compaction of soils. In this aspect the critical level of compaction was established, at which achievement of a plants begin to test deficiency of soil air (Kachinski, 1965).

The development of representations about optimum and equilibrium density received wide use and indicated to diagnostics of a condition of soil depending on application of the instrument of cultivation and technologies. It has enabled more is proved to choose instruments and methods of cultivation.

By the author of the present work it is offered to use parameters of soil density for an estimation of a number of elementary pedogenesis processes: desalination, desilting, kaolinization**,** gleyization and others (Jigau, 1994, 1998, 2000).

The wide application is found by the parameters of soil density with the purposes of diagnostics of anthropogenesis elementary processes proceeding in processable soils (Jigau, 1994)**,** and the dates of dynamics of this parameter have allowed to distinguish three phases in functioning of process able chernozem (Jigau and etc., 2006). In a basis of the marked works the principles of the concept about pore space of soil are fixed.

The basic postulates of this concept are elaborated in the works of Voronina (1981, 1984, 1986,1989, 1990). By the marked works is established, that the soil as polyphase functioning system is valuable not so much by firm particles, how much by pore space created by them, as all soil processes proceed in pores. Micro and macro vacuity represent spatial niches occupied by different groups of organisms (microorganisms, skeleton less), so in pore space all vital processes (biochemical processes) ensuring reproduction of soil system proceed also.

Proceeding from this it is possible to conclude, what the functioning of soil ecosystem is determined in volume, sizes and stability of pore space of soil. A structure of pore space is a function of granulometric composition, contents of humus, crumbling of soil and soil structure as the method of packing of firm particles.

By numerous works is established, that than more hardly the granulometric composition, the less than volume of the general pore space and that more adversely the differential pore space of soil. At same granulometric composition the volume of pores and their distribution on the sizes is determined by parities between fractions of sand, dust and clay. Increases of the contents of humus promotes of crumbling of soil weight and improvement of a mode of pore space of soil. In this context the soil density of ad is size integrating a role in forming of pore space, which can be expressed by the following equation (Medvedev and etc, 2004):

$$\rho = 1{,}20 + 0{,}004X_1 + 0{,}004X_2 - 0{,}002X_3 - 0{,}04X_4,$$

where, ρ – soil density, g/cm^3;

X_1 – contents of physical sand (particle of 0,01 mm), %;

X_2 - factor of flocculation, %;

X_3 - contents of air-dry aggregates of 10-0,25 mm, %;

X_4 - contents of humus, %.

The stability of pore system is connected to stability of soil structure, including with properties of a soil matrix.

On the basis of all above-stated it is possible to conclude, that the soil density is connected directly to a type of pedogenesis and at the same time is the factor determining intensity both orientation of processes of development and evolution of soils.

In the simplified sight this communication can be expressed through modes of receipt and charge of a moisture, aeration, growth of roots, exchange processes and another. The too much friable soil assumes bad contact of soil with roots of plants, increased evaporation, low concentration of a moisture and food in the unit of volume, deterioration of basic function of soil for roots and another. For process of pedogenesis all conditions for mineralization of the root rests up to final products and aridization of a soil body here are created.

In the puddled conditions of soil the process of pedogenesis gets other orientation. Its characteristic features are degradation of biological proprieties and domination of restored connections. Moderate average configuration (the optimum intervals of sizes of soil density) provide the most favorable conditions for course of elementary pedogenesis processes of components essence of this or that type of pedogenesis.

The mode and tendencies of evolution density chernozem's of Moldova

Being a physical parameter which characterizes a firm phase, the soil density is inherited from native rock, it mineral and texture composition. At the same time, by numerous researches is established, that the soil density of addition on the contents of humus, the composition of the absorbed bases, degree of micro and macro crumbling and other factors of a soil origin, in this connection the soil horizons are less compacted, than soil-forming rock.

It allows to consider, that this parameter is connected directly with processes of pedogenesis, in this connection, each type of soil characterized to him by an inherent mode of density, and the degree of decompacted of the active soil functions layer can be used with the purposes of an estimation of intensity of process of pedogenesis and level of physical change of rock by pedogenesis processes. Last depends on a type both of age and the nature of pedogenesis process and degree of a pliability soil forming rock to physical changes. In turn, its depends on age and nature of native rock its chemical, mineralogic and granulometric composition.

The chernozems of Moldova, in the majority, were formed on quaternary deposits mainly average and heavy clay loam granulometric composition of a various origin (eluvial, deluvial and others). Therefore it the mode of density not ploughed up of chernozems of region has many general attributes:

- minimal dates in the top genetic horizon and smooth, but rather fast, increase of dates in subsequent 2-3 horizons; attenuation, alignment and fixing of dates in the bottom horizons and in rock;
- the distinctions in granulometric composition and in quantity of humus poorly influence on the character of profile distribution of soil density. In

leached chernozem with texture-poorly differentiation the profile marks some increase of soil density in horizon B (t);

- at identical of granulometric composition in a genetic line the tipical chernozem of average humic - the typical chernozem prehumic – the chernozem carbonat the dates of soil density are increased, that is called by decrease of a structure degree of soil weight and smaller water penetrability of structure. The water unstable structure soaks in the damp period of year results in more dense packing of soil weight, and subsequent dry up of soil causes its settlement - consolidation and increase of soil density;
- by greatest reworking in relation to rock is characterized the root layer, that is called by development of sward process of pedogenesis in this layer, aggregation and, especially, micro aggregation.

This is promoted by prevalence of humic acids in the structure of humus and domination of calcium in a soil absorbing complex.

All above marked puts soil density in a line of parameters dependent from a type of pedogenesis and at the same time in a line of the important parameters on which it is possible to estimate the pedogenesis process.

Being depending on a line of the steady soil factors (granulometric composition, contents of humus and others) the soil density finds out close connection with the soil moisture. The influence by last on soil density has multilateral character, main it that the moisture determines a direction, speed, intensity and power of processes of mechanical, physical, chemical, biological, biochemical and other nature proceeding in soils.

The moisture determines dynamics of elementary soil processes, and through them and the dynamic of soil density. In an annual cycle the dynamic of soil density of Moldavian chernozems assumes two periods. The first period in time coincides with the growth period (April - September) and is characterized by progressive increase of soil density. The dynamic of the soil moisture during this period carries return character. At the same time, the process of loss of a moisture by soil proceeds more intensively, than process of compaction. It is connected, with that what at during dry up the soil loses first of all moisture contained in readily draining and draining pores, which practically does not influence on a mode of soil density (Jigău 2004).

The progressive increase of soil density occurs at evaporation of a moisture contained in moisture conduct pores (interval of moisture, contained in an interval, of humidity fault of capillary connection – humidity wilting).

The second period assumes autoloosen, reduction and reproduction of equilibrium dates of soil density. In time it covers the cold period of year (November - March).

Depending on dynamics of soil density and processes its determining in a structure of not ploughed up chernozems stand apart three layers.

First covers a root layer and is characterized by the greatest amplitude of dynamics of soil density, which is caused by the phenomena of heating - cooling, humidifying – drying up and structuring - destructuring. An essential role in dynamics of soil density in this layer have the biochemical processes of decomposition of organic remains, and also processes of development of root system.

The second layer covers transitional horizons (B_1, B_2). In this layer, the dynamics of density is determined, mainly, of processes of humidifying – drying up and only by partially biological phenomena and processes of structuring in this connection, the amplitude of dynamics is essentially reduced, and in the bottom part of a layer fades.

The third layer covers carbonate illuvial horizon (Bca) and native rock and is characterized by stable dates of soil density.

From all above stated follows, that each factor determining dynamics of soil density renders dual influence on soil. On the one side, this is compaction, with another side this is decompaction, owing to what the soil density in naturally conditions is dynamic equivalent size characteristic for soil-climatic and of edaphot conditions (Table 1).

The table 1

The equilibrium soil density of typical chernozem, prehumic, heavy clay on clay loam (g/cm^3) (area Glodeni)

Depth, cm	1968*	1991	2001
0-10	1,03	1,07	1,00
10-20	1,06	1,11	1,02
20-30	1,17	1,16	1,09
30-40	1,23	1,20	1,11
40-50	1,28	1,29	1,22
50-60	1,28	1,29	1,23
60-70	1,31	1,29	1,30
70-80	1,29	1,34	1,32
80-90	1,33	1,33	1,30
90-100	1,37	1,34	1,36
110-120	1,40	1,43	1,39

The data belong V.V. Vitiu and E.Z.Rabinovich (1968)

In the agro ecosystems the equilibrium soil density is determined by the same factors with which is determined in the natural ecosystems (granulometric and mineralogical composition and etc.) at the same time, it dynamics is complicated by inclusion of processing in number of the factors which its

determining. Thereof in a mode of soil density of chernozems's plough are allocated 4 range:
- minimal density established in soil after the basic deep cultivation and formed < 1g/cm^3 (September - October). To the beginning of the cold period it already makes more than 1,20 g/cm3 (1,22-1,28 g/cm^3);
- the equilibrium density (1,05-1,20 g/cm^3), established in the soil by the end of the cold period to the beginning of growth;
- the optimum density (1,13-1,30 g/cm^3) kept in the soil up to the end of May -the first decade of June;
- the critical density (> 1,35 g/cm^3) kept in the soil since the second decade of June up to the end of the growth period (September). Depending on climatic conditions of year the soil density can reach 1,45-1,50 g/cm^3. Such sizes were repeatedly fixed by us, and, decompacted of such compacted soil occurred slowly, and in conditions of droughty weather it was failed at all.

Monitorization of a mode of soil density of plough chernozems specifies the steady tendency of compacting soil. To the present time to this process are exposed from 53 up to 87 % of plough chernozems. The mechanism of compacted and factors their determining were examined by us in a number before the works published (Jigau, 2000; 2004; 2006). Here it would be desirable only to note, unfortunately, that in the literature this phenomenon is often examined as a result of simple compression of soil, and the effect of compaction can simply be removed by agro technical methods.

By our researches is established, that in a case of compacted soil there is a mutual displacement of structural aggregates owing to what total volume of pores and interaggregate porosity decreases. Alongside with it, there is also compacting of aggregates. Last arises owing to cultivation of soil in a damp condition and is accompanied by increase of water firm structure. At the same time, this phenomenon cannot be attributed to positive, as occurs at the expense of reduction aggregate porosity. Moreover, to restore density and aggregate porosity by cultivation it is impossible, and for autocompacting the time is required, which duration is determined by granulometric and mineralogical composition of soil, and also their hydrothermal mode. With the greatest intensity processes of the aggregate compacting and decrease of the aggregate porosity are carried out in the top horizon. In under top horizon of soil with the greater intensity the processes resulting to reduction of volume of interaggregate porosity proceed. The greatest degree of deformation of soil structure here is marked.

Linearly with increase of density grows the hardness and specific resistance of soil by crumbling.

The functional - genetic changes of soil under influence of compaction.

The contents and orientation of pedogenesis processes is accepted is for considering examining mainly depending on the natural factors of a climate, vegetation, relief, native rock, time. In the same determined connection the properties of soil and basic modes are usually estimated.

Unfortunately down to the present time without attention there is a back connection soil
- > the factors, and also the role of internal (soil) factors in pedogenesis which materialization in the ecosystems soil's functions (Table 2).

The table 2

The ecosystems soil's functions (Dobrovolski, 2001)

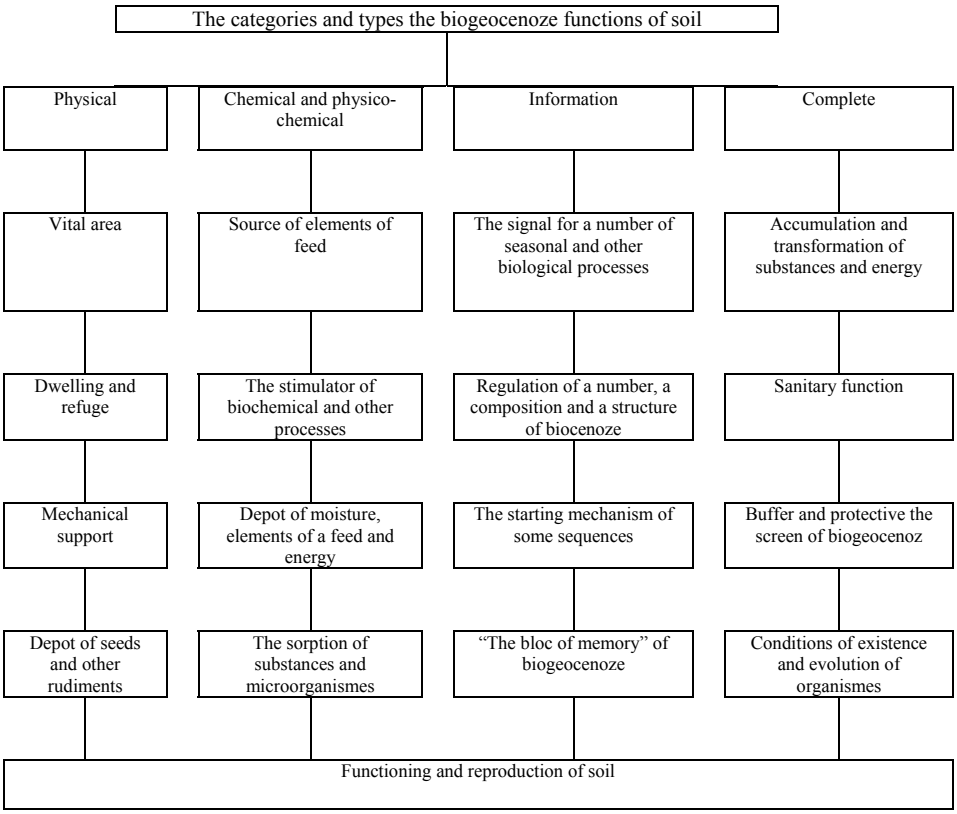
Physical ↓	**Chemical and physico-chemical** ↓	**Biological** ↓	**Information** ↓
Vital area	Accumulation of biofil elements	The environment inhabit of organisms	Regulators of ecosystems structure
Mechanical support	Accumulation of ferments	A link of biological cycle of substances and energy	The signal systems of changes of condition ecosystems
Accumulator of a moisture	Accumulation of biochemical energy	Biological efficiency (fertility)	Record and storage of parameters of a ecosystem's history экосистем (soil - memory)
Three-phase system	Sorption of substances (adsorbing capacity)		
Protective ecological function	Sorption of microorganisms		
The depot of seeds, embryons	Destructization and mineralization of organic traces		
	Resynthesis of organic and mineral substances		

The factorial analysis of the above-stated functions shows, that the majority of them are determined by a mode of soil density. Among them the greatest importance have functions of biogeocenoz. They undergo the most appreciable changes under influence of compaction
(Tab. 3).

Change of complete functions is caused by features of a water-air mode folding in the soil owing to compaction. By numerous researches is established, that the compaction of soil condensation is accompanied by degradation of biovariety soil biota or disappearance and reduction of number of a line of communities of microorganisms. At the same time it is known, that for maintenance of ecological balance of soil system it is important, that each greatest site of soil contained all set of various microorganisms necessary for realization destruction of acting from the outside substances. With it is provided the homestatistic condition in soil, which assumes certain, characteristic for this type of soil a set of chemical and other properties.

The table 3

The functions of biogeocenoz of soil varied owing to anthropogenous compaction



At occurrence of shifts in system of receipt of the fresh vegetative rests or mineral fertilizers the microorganisms actively are included during their transformation and result system in a condition of balance. In a case when this system is disturb in the soil remain the subdecomposed substance, and their gradual accumulation causes a toxicological condition.

The special attention is deserved by a problem of degradation of herbicides, insecticides and dust-gas refuses. One of the methodical approaches of regulation microbiological processes of destruction of the above named substances in soil is the purposeful influence on soil with the purpose of creation of necessary conditions for intensification of degradation process of the organic substances of technogenetic origin.

It assumes, first of all, the system of agrotechnical methods directed on optimization of a mode of soil density and creation of favorable conditions for development of groups of microorganisms capable to spread out toxic organic substances of technogenetic origin before simple harmless connections. Thus it is

necessary to take into account, that the adverse conditions, can cause the processes of herbicide transformation in soil, the connections having greater toxic can be formed than initial connections, therefore very important to achieve optimum parameters of soil density and soil porosity.

From information functions under influence of anthropogenous compaction the greatest changes are undergone by regulation function of biocenoz structure. The influence of soil density on volume and structure as vegetative, and microbial communities has an effect through water-air, temperature and food modes of soil, which determine the germination of seed plants, crates and dispute of the microorganisms. On the other side the marked soil modes have paramount importance in formation and condition both of fito-, and microbcenozes**.**

The most essential changes under influence of anthropogenous compaction of soil undergo the physical and biogeocenozes functions of soil, which characterize the soil as vital area, dwelling and refuge for micro and macro organisms.

The concept of soil as a complex of polidispersion three-phase system, as an environment inhabit of the diversified groups of animals, was developed by M. S. Gilerovim (1968). With reference to the world of microorganisms the concept about the as set of an environments inhabits was entered by D.G. Zviagincev (1978). The quoted author marked, that thanked to its structures and microzonality the soil should be examined as a set completely various micro- and macromediums in each of which are created completely various and often of a contrast condition for development of separate groups of microorganisms.

The measure of quality of physical biogeozenozes functions of soil is soil density. The most favorable conditions are created on a background of optimum dates of density. The compaction results in an establishment in soil of the extremely adverse conditions for development of microbcenozes.

The reduction of total volume of pores пор and interaggregate porosity is accompanied by reduction water-and air permeability of soil and results in deterioration of water-air and oxidation-reduction of soil modes. Alongside with it the depth drench of a soil profile decreases, that, even for the rather short period of time, was reflected adversely on the balance of bio- and pedogenesis products.

Essential changes undergoes the differential porosity of soil.

By researches is established, that the compaction of soil aggregate is accompanied by reduction the volume of moisture conduct pores and increase the volume of moisture holding pores. The volume of pores which engaged by a adsorptive moisture is increased almost twice.

The marked changes result in reduction by the least moisture capacity, increase of the humidity of break of capillary connection and the humidity of stability fade. Thereof a range of an active moisture essentially changes (Table 4).

The table 4

The evolution of differential porosity and hydrophysical properties of soil under influence of compaction

Soil density g/cm^3	Total porosity %	Differential porosity, %					Water proprieties ,%		
		<0,2µ	0,2-1,0µ	1,0-10,0µ	10-300µ	>300µ	Humidity of fade	Least moisture capacity	Diapozon of active moisture
1,00-1,25	54,7	7,3	8,8	24,0	7,9	6,7	10,3	28,8	18,5
1,26-1,40	48,5	10,8	9,2	19,6	5,9	2,8	11,4	27,6	15,2
1,41-1,45	46,7	11,3	9,4	20,0	4,3	1,7	12,0	26,9	14,9
1,46-1,50	43,7	13,2	10,4	18,2	1,9	0	12,6	26,3	13,7
1,51-1,55	42,0	16,9	10,5	12,9	1,7	0	13,3	26,4	12,8
1,55-1,60	39,7	16,9	10,3	11,2	1,3	0	14,8	25,5	10,7

The marked changes alongside with processes of a deepening of base erosion are major factors and components of aridization of soil cover at the present stage of pedogenesis.

Alongside with it is established, that the soil compaction and the reduction of the contents of large pores and deterioration of aeration results in decrease of the contents of oxygen and increase of the quantity of carbonic acid in soil air, that in turn results in infringement of a nitrate mode and deterioration of mastering by plants of nitrogen, phosphorus and potassium.

The decrease of water penetrability and water ability results in increase of water quantity which is spent on a superficial drain. At the same time, the reduction of volume of interaggregate porosity in the under top layer interferes with vertical movement of a moisture on a soil profile and its accumulation in the top horizon. In the period of early spring and during plentiful deposits the humidity of top horizon reaches a level of the bottom border of fluidity. It is the basic reason of the greatest risk of soil erosion in the early spring period of year.

The marked changes of pedogenesis modes result in change of an orientation and intensity of pedogenesis processes (Table 5).

The table 5

Ecologo-genetic consequences of compaction of cultivable chernozems soil (Medvedev etc., 2004)

Criterion	Change of the processes of contents and orientation	Consequences
Humification-mineralization	Accumulation inside of aggregate the products of incomplete decomposition and their inclusion in the humus connection	Loosen the chernozem process of pedogenesis
Microbiological and	Decrease and degradation of a	Partial (mosaic) degradation of

biochemical activity	biovariety and activity of soil biota	biological proprieties of under top soil layer
Transformation of elements in the systems solid phase –soil solution	Decrease of a correlation the soil: a solution, increase the volume of the thermo dynamic connected moisture	Preservation of elements in aggregates, decrease by their ascending and descending migration ability
Transformation of substances within the framework of the large and small circulations	Reduction the speed of transformation substances, weight of substance participating in transformation, capacity of active horizons	Loosen of the chernozem pedogenesis
Firm and liquid superficial drain	Spatial differentiation of substances in a landscape	Amplification of erosion processes
Pollution of the lowered elements of a landscape and reservoirs	Carry of pollution	Accumulation of contaminants and increase of probability of ecological risk

Monitorization of soil density specifies on three periodss, clearly differing in an annual cycle, on intensity and orientation of pedogenesis of processes. The most favorable conditions for course " processes of chernozems " are created in spring and in the early summer time (April - June) the humidity of soil is close to least moisture capacity, and soil density makes 1,1-1,3 g/cm^3. In this period the total porosity makes 55-56 %, and the porosity of aeration is 20-25 %. This period is characterized by the greatest activity of biological processes both active chemical and physico-chemical processes which determining the oxidation-reductions and acid-alcaline conditions favorable course all micro-, mezo- and macroprocesses inherent to chernozems type of pedogenesis.

The summer-autumn period (July - October) is characterized by sharp reduction of moistute stocks and increase of soil, that results in reduction total porosity and the volume of moisture conduct pore and to increase the volume of moisture holding pores. Thereof in the soils the intensity of a number of biological, chemical and physico-chemical processes decreases. Simultaneously arise and develop the new microprocesses caused by deficiency of humidity and intensive warmed of soil.

The cold period (late autumn - winter- early spring) differs by intensive processes of reproduction of the basic physical characteristics of chernozems and realization of chemical-biological processes promoting the desalinization products of bio- and pedogenesis, and also partial loss of carbonates.

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