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Research Article

Interpretation of the Soil Physical Properties through the Sign System

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Abstract

Interpretation of the soil physical properties through the sign system is result of long-term field experiments related Estonian soil and climatic conditions were carried out. Elaboration of suitable method and relevant results related levels of pedosemiotics have been obtained. In this result, 4 different pedosemiotics levels are proposed which are: a more favourable level (MFL), favourable level (FL), to be sparing with something level (SSL), unfavourable level (UFL). The three different types of farming based on above four levels of pedosemiotics were evaluated which are following: intense farming (No 1), normal farming (No 2), organic farming (No 3). The main indicator of evaluation is soil bulk density (SBD), the various levels of which served as the basis for identifying the index of soil density (ISD). The results of calculation of the ISD which is based on comparing different types of farming with regard to the above pedosemiotics levels were provided. According comparative assessment based calculation of ISD concerning pedosemiotics sensitivity through a two different options for choosing of two variants of the minimum SBD (minimum SBD = constants and minimum SBD = var) the results was that the first variant was a more sensitive. The metaphor such a new element of evaluation as a while simultaneously evaluating pedosemiotics levels were provided. Its have a relatively good generalization, visualization and symbolical information, i.e. with MFL - the so-called grandmother's bed; with FL - the least soil vulnerability; with SSL - a moderate soil vulnerability; and with the UFL - the soil is firmly compacted.

Keywords: *Soil; Physical Properties; Soil Bulk Density; Index of Soil Density; Sign System; Metaphor*

Introduction

Mankind engaged in agriculture for centuries has been able to understand the complex natural signs. Without such wisdom it was impossible to obtain of the daily bread on the table. This wisdom has been handed down from generation to generation up to near-time [1].

Now, when satellites are flying around the earth and modern agricultural equipment, equipped with various sensors and GPS, and when the operators with the headphones and with slippers is sitting in the cabs of the machines in an ergonomic conditions, at the same time he has already lost his direct connection with the field and with its soil. If for soil it does not like something, but after that we can find out about it not immediately, then after a certain time it will be too late already. Unfortunately, after that the correction of errors in this case will be associated with additional costs [2].

Therefore, as supporters of technical progress, we adhere to the practice of walking across the field to take the soil in our hands and even to smell it. Not only once but constantly monitor the physical condition of the soil. It seems to us that the most important indicator of the soil physical properties should be considered the soil bulk density (SBD) [3]. This indicator has the most significant impact on the growth and evolution of plants [4].

As a general introduction to the sign system, it should be noted that these systems were first used not in agriculture, but in linguistics [5]. Later they found wide application in philosophy [6]. From there they spread to other areas of science including agriculture [7]. In Estonia, scientists began to study the problems of sign systems or semiotics in the first half of the last century [8]. Therefore, it is quite natural that the problem of sign systems has found its application in our research [9].

In general, semiotics can be understood as signs, their systems and communication processes, as well as system indicators of an object under investigation, in which sign systems are connected with its descriptive character through appropriate codes [9].

It is relevant to mention what is here the role of metaphor [1], which has not yet been widely used in agriculture. Without of deep analysis of the various functions of the metaphor (informational, representative, explanatory, hypothetical, comparative, economical) [9], it should be emphasized about special role of metaphor in semiotics. If we transfer this point of view to our field of research, we can use the metaphor to characterize the result of positive and negative farming.

At the same time, it is possible to clearly characterize its level and the level of the soil physical properties (in this case, the SBD) through a well-chosen metaphor in contrast to complex theoretical calculations and scientific hypotheses. The main thing is that the scientific results become more comprehensible and illustrative [1].

The specific feature of our methods is that we have been tried to obtain adequate answers to the questions related corresponding levels of soil bulk density. "We look upon soil as a living being, so we can speak of the sign system, i.e. pedosemiotics" [9] and at the same time the state of its 'health'. It means that we can try to characterize it in some way through respective assessment criterion [11].

Based on the above, the goal of our research was to develop a new system of pedosemiotics evaluation of the result of farming through such an important indicator as ISD, which is the definitive result of the evaluation of agricultural technology, in general the soil physical properties particularly.

Materials and Methods

Experimental Sites, Extremes of soil bulk density

The most favourable level of soil bulk density (like something that as grand mother's bed) is equal to 0.95 - 1.02 Mg m^{-3} which is as minimum level (first extreme) when its determined during spring sowing and after earlier autumn ploughing. For Estonian conditions that is quite typically agricultural farming.

The current levels of soil bulk density (SBD) were measured at field located in several districts of Estonia, i.e. beginning of field experiments and after that also usually end of above. The sites are located at (No 1 - 58°56´N, 22°26´E (intense farming); No 2. - 59°13´N, 27°20´E (normal farming); No 3 - 59°04´N, 24°21´E (organic farming) [12].

Determination of unfavourable or maximum level of the soil bulk density is carried out in laboratory conditions. For this is used the special equipment - oedometer (apparatus for soil consolidation), and in result of this the level of soil bulk density - SBD is achieved up to 1.79 Mg m^{-3} which is quite maximum level (second extreme) [14].

Theoretical Preposition

According assessment of the soil bulk density (SBD) through the sign system, it is important to obtain such a diagnostic indicator whereupon is possible clearly describe the corresponding level of soil physical properties depending of various farming system including corresponding soil management. For this we are specially made up a corresponding formula [1]:

$$\text{index of soil density (ISD)} = \frac{(currentSBD - \min SBD)x \max SBD}{(\max SBD - \min SBD)xcurrentSBD}$$

In the result of investigations we could be ranked the corresponding level of character ISD in accordance with the sign systems related corresponding levels of pedosemiotics, i.e. a more favourable level (MFL), favourable level (FL), to be sparing with something level (SSL)

and unfavourable level (UFL). Having the possibility of such an assessment, it is already not difficult to characterize from the soil point of view the result of applying any type of farming. Despite common knowledge of this index of soil density (ISD) however should emphasize its significance in the evaluation of the results of farming.

Statistical analyses

The statistical estimation of data of the SBD has been carrying out by t_{05}-criterion of Student. Least significant difference (LSD) test as of right was used.

Results and Discussion

Pedosemiotics levels of SBD

In order to achieve results of some of our field and laboratory experiments, to find the extreme (best/worst) values for the above mentioned SBD, it could be fixed that, logically, the theoretically a best level is equal to 0.95 Mg m^{-3} and the worst level - 1.79 Mg m^{-3} [13]. Hereby, it should be emphasized that the best level of SBD for several kind of trials is different, but for different trials the worst level of SBD it was assumed to be 1.79 Mg m^{-3}.

Regarding to describe the corresponding level of soil physical properties depending of various farming system are presented in table 1 [12]. It seems that difference between normal and organic farming is not significant. At the same time the difference between above mentions type of farming (No 2 and No 3) and intense farming (No 1) is mostly significant different. Another fact that draws attention is that with an intense farming in comparison with an organic farming, the SBD indicators differ more significantly with pedosemiotics indicators of MFL, SSL and UFL

Trial	Pedosemiotics level of SBD, Mg m^{-3}			
	MFL	FL	SSL	UFL
No1 (58°56´N, 22°26´E)	1.09 - 1.19	1.20 - 1.29	1.30 - 1.49	1.50 - 1.79
No2 (59°13´N, 27°20´E)	0.96 - 1.16	1.17 - 1.27	1.28 - 1.45	1.46 - 1.79
No3 (59°04´N, 24°21´E)	0.95 - 1.15	1.16 - 1.26	1.27 - 1.44	1.45 - 1.79

Table 1: *Levels of current soil bulk density (SBD) depending of various farming systems.*

(Trials: No 1 - intense, No 2 - normal, No 3 - organic).

LSD at P ≤ 0.05 for No 1 = 0.03 Mg m^{-3}.

LSD at P ≤ 0.05 for No 2 = 0.05 Mg m^{-3}.

LSD at P ≤ 0.05 for No 3 = 0.04 Mg m^{-3}.

The next step is to determine the index of soil density (ISD) according to the SBD data given in table 1. First of all, the values of the SBD extremes should be clarified. As for the maximum SBD, there are no questions. This maximal indicator for all types of farming management related the number from the 1st to the number 3 is remaining the same - 1.79 Mg m^{-3}.

As for the minimum SBD value, there are for all the considered experimental options a two ways here to accept or not to accept regarding the minimum SBD. Then, at the earliest opportunity, it will be possible to assume that all pedosemiotics characteristics ranging from MFL and ending with UFL will be less random (Table 2).

Trial	Pedosemiotics level of SBD and (ISD)			
	MFL	FL	SSL	UFL
No1 (58°56´N, 22°26´E)	0.27 - 0.43	0.44 - 0.56	0.57 - 0.77	0.78 - 1.00
No2 (59°13´N, 27°20´E)	0.02 - 0.39	0.40 - 0.54	0.55- 0.73	0.74 - 1.00
No3 (59°04´N, 24°21´E)	0.00 - 0.37	0.39 - 0.52	0.54 - 0.73	0.73 - 1.00

Table 2: *Levels of index soil density (ISD) depending of various farming system.*

(Trial: No 1 (intense farming) - minimum SBD =.095 Mg m^{-3}; trial No 2 (normal farming) - minimum SBD = 0.95 Mg m^{-3}; No 3 (organic farming). - minimum SBD = 0,95 Mg m^{-3}).

LSD at P ≤ 0.05 for No 1 = 0.06.

LSD at P ≤ 0.05 for No 2= 0.05.

LSD at P ≤ 0.05 for No 3 = 0.06.

In the final solution of the formula for determining ISD, taking into account the compared variants of the considered types of farm management, it should be emphasized once again that they all start from the same reference point of SBD (0.95 Mg m^{-3}). At the same time, it is possible to imagine that this pedosemiotics system is clamped in a closed like something box, i.e. all considered intermediate indicators of ISD are inside this imaginable box.

From the analysis of the above mentioned formula it also clearly follows that the ISD changes in proportion to the current values of the SBD, and if this SBD is smaller (more favourable) then the proportionally an important result of the ISD also will be less.

When comparing the alternative approach (not to accept regarding the minimum SBD) related each experimental variant (No 1, No 2 and No 3) which has the minimum different meaning value of the SBD, then in this case the pedosemiotic picture will be completely different (Table 3).

Trial	Pedosemiotics level of SBD and (ISD)			
	MFL	FL	SSL	UFL
No1 (58°56´N, 22°26´E)	0.00 - 0.21	0.23 - 0.40	0.41 - 0.69	0.70 - 1.00
No2 (59°13´N, 27°20´E)	0.00 - 0.37	0.39 - 0.53	0.54 - 0.73	0.74 - 1.00
No3 (59°04´N, 24°21´E)	0.00 - 0.11	0.39 - 0.52	0.54 - 0.73	0.73 - 1.00

Table 3: *Levels of index soil density (ISD) depending of various farming system.*

(Trial: No 1 (intense farming) - minimum SBD =.09 Mg m^{-3}; trial No 2 (normal farming) - minimum SBD = 0.96 Mg m^{-3}; No 3 (organic farming). - minimum SBD = 1.09 Mg m^{-3}).

LSD at P ≤ 0.05 for No1 = 0.08 Mg m^{-3}.

LSD at P ≤ 0.05 for No2= 0.05 Mg m^{-3}.

LSD at P ≤ 0.05 for No3= 0.09 Mg m^{-3}.

In this case, attention is drawn to the fact that, despite the comparison of theoretical approaches, the reference point (minimum of SBD) is different however the result of ISD at the most favourable pedosemiotics level of MFL starts from zero while in the first alternative scenario (Table 2). These points of reference are different for the above experimental farming options.

A theoretical analysis of these two alternative approaches showed that the pedosemiotics sensitivity of the first alternative approach is higher, which indicates its higher representative. In general, as can be seen from the results obtained the choice of this or an alternative approach has little effect on the way No 3 farming (Table 3). At the same time, this alternative approach has slightly underestimated the values of the ISD indicator, which is one more confirmation of the lesser pedosemiotics sensitivity of this (Table 3) alternative approach.

Which of these approaches should be preferred? The answer to this query depends on the objectives of the research. If the goal is to research and compare types of farming in terms of a sign system, then it is clear that the first option would be preferable. At the same time, it is interesting to note that when calculating the ISD indicator then concerning the method No 3 of farming only the imaginary evaluation box within the limits of 0.00 (MFL) to 1.00 (UFL) was closed. The remaining methods are well comparable with each other (Table 2).

If we take for the purpose of research the comparison of types of farming from the point of view of agrotechnology, here it is certainly that the preferences should provide a second alternative approach (Table 3). In order to better understand of the principles our theoretical analyses we have adapted such concept as imaginary box [15]. Hence, despite the fact that our imaginary box was not closed on all the same minimum SBD for all variants of farming, nevertheless, our imaginary box was closed automatically on both sides and for all of the considered variants of farming. Figuratively speaking, we have, as it were, three separate boxes that can be reliably compared. It is interesting to note that the indicator of ISD with both alternative approaches to the type of farming No 2 (normal farming) remained unchanged.

In order to better comprehend our proposed pedosemiotics levels, we should refer to the corresponding metaphors about which we have already spoken above. It seems to us that in our case of all the various functions of metaphor we are dealing with a comparative metaphor, since a comparison is made between the best physical condition of the soil and the worst.

It is quite clear that there is no more successful metaphor for describing a better physical condition of the soil as a grandmother's bed (pedosemiotics level - MFL). And vice versa - tightly compacted soil (pedosemiotics level - UFL) resulting from the worst soil physical properties. Since there are also intermediate states between these two extreme metaphoric characteristics, one can accept the metaphor - the vulnerability of the soil. For a more detailed description of the remaining intermediate pedosemiotics levels of the soil physical properties, one can accept for the FL metaphor - the least vulnerability and for SSL - the moderate vulnerability of the soil.

As a result, it should be emphasized that in our case, the metaphor plays a significant role when comparing different methods of farming among themselves. Its role is difficult to overestimate, and it is so indisputable that it can even make up the difference between the two different and versus proposed approaches for assessing the soil physical properties - the pedosemiotics and agrotechnological. Hereby, due to note that "metaphorical utterances do have special communicative effects" [16].

Conclusions

From the obtain results we conclude that a theoretical approach to interpreting the soil physical properties through a sign system were developed. At the same time, it is quite clear that related comparing the various types of farming the pattern of transition from physical to symbolic indicators is visible. Using a relatively simple formula (ISD) for assessing and compare the soil physical properties of different types of farming in terms of both agrotechnology and pedosemiotics was made. As a result, it was verified that in identifying appropriate pedosemiotics levels an approach with a constant minimum SBD has better pedosemiotics sensitivity than an approach with a variable minimum SBD. Due to a successful metaphor for description of pedosemiotics levels allows giving good visibility and informative generalization.

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