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CONSTRUCTION OF A DIAGNOSTIC ALGORITHM FOR SOIL IDENTIFICATION ACCORDING TO THE INTERNATIONAL SOIL CLASSIFICATION SYSTEM WRB

Abstract. Topicality. In this article discusses the identification of soils according to the international soil classification World Reference Base for Soil Resources system (WRB). The World Reference Base for Soil Resources was developed to identify soils and use the obtained data in different areas of everyday life: agriculture, forestry, animal husbandry, etc. **The purpose of the work** Note that the WRB, developed by a group of soil scientists, is not meant to replace national classification systems. Besides this classification system, there are also different soil classifications designed by national soil science schools. The difference in the structures of these classifications necessitated the development of a diagnostic algorithm to correlate them with each other. **Results** Three options for determining whether a soil belongs to reference soil groups are considered, depending either on soil parameters only, or on a combination of diagnostic horizons and soil parameters, or only on diagnostic horizons. A group of scientists headed by M. Babayev also developed a national soil classification system for Azerbaijan. In order to compare these two systems, this study proposes a soil data structure, as well as an algorithm for soil identification according to the WRB classification on the basis of the proposed structure. **Conclusion** A soil diagnostic algorithm is developed, which will allow identifying any soil type with the corresponding WRB Reference Soil Group. Three variants of allocating soils to WRB Reference Soil Groups based only on soil parameters, or on the combination of diagnostic horizons and soil parameters, or only on diagnostic horizons are considered.

Keywords: diagnostic algorithm; database structure; soil identification; soil group; diagnostic parameters.

Introduction

The World Reference Base for Soil Resources (WRB) [1] was developed to identify soils and use the obtained data in different areas of everyday life: agriculture, forestry, animal husbandry, etc. Note that the WRB, developed by a group of soil scientists, is not meant to replace national classification systems. Besides this classification system, there are also different soil classifications designed by national soil science schools. The difference in the structures of these classifications necessitated the development of a diagnostic algorithm to correlate them with each other. A group of scientists headed by M. Babayev also developed a national soil classification system for Azerbaijan [5]. In order to compare these two systems, this study proposes a soil data structure, as well as an algorithm for soil identification according to the WRB classification on the basis of the proposed structure.

Problem Statement

The following objectives are set in this paper:

- Development of a data structure for soil types in the Reference Soil Groups (RSG) of the World Reference Base for Soil Resources (WRB);
- Development of a diagnostic algorithm according to the WRB soil parameters on the basis of the developed data structure.

An analysis of allocating soils to a particular WRB RSG was conducted in order to construct a diagnostic algorithm. Note that WRB is a two-tier system of soil classification, with the first level containing 32 major RSGs, and the second level assigning a set of principal

and supplementary qualifiers to each RSG [3–5]. Soils are allocated to RSGs on the basis of principal soil parameters. In this paper, the first level of allocating soils to RSGs is considered.

A structure of the database of principal soil parameters collected in the order of their comparison with RSGs is proposed. A diagnostic algorithm is developed for the principal soil parameters enabling the allocation of a soil to the appropriate reference base of soil resources.

Soil Data Structure

A detailed study of works of soil scientists revealed that soil parameters can be grouped into the following three classes:

- Measured directly in the field (numerical value);
- Determined by laboratory analysis (numerical value);
- Determined on the basis of expert opinion (listed variants).

A tabular structure of the soil data under consideration is proposed for conducting diagnostics. In accordance with the listed grouping, these tables can store data in interval form, in the form of specific values as well as enumerated values [6, 7]. The primary table contains the principal indicators identifying soil types accordingly to the RSGs. Each of the fields in the primary table of the database structure contains information about a specific soil indicator and has its own unique name and type of definition. It should also be noted that some soil parameters from the primary table are linked to auxiliary tables, which contain a full description of this parameter. For instance, a soil may contain soil materials of various

types; therefore, the field in the primary table, which indicates the content of any material in the soil, is linked to the auxiliary table, which includes the names of all types of soil materials considered in the soil diagnostic algorithm.

Script of the main table:

```
CREATE TABLE [dbo].[Soil_Indicate]
  [IDTABLE] [numeric] (18, 0) NOT NULL,
  [ANTROPOQEN] [bit] NULL,
  [MINERAL] [bit] NULL,
  [ORQANIK] [bit] NULL,
  [UP_HORIZONTAL] [bit] NULL,
  [PODPOVERX_H] [bit] NULL,
  [SREDNIY_H] [bit] NULL,
  [NIJNIY_H] [bit] NULL,
  [PEREXOD_H] [bit] NULL,
  [MOSHNOST] [int] NULL,
  [TEMPERATURE] [nchar](10) NULL,
  [QRUNTSU] [bit] NULL,
  [MATERIAL] [int] NULL,
  [QLUBINA] [int] NULL,
  [OSTATOKMXA] [float] NULL,
  [CVET] [varchar] (50) NULL,
  [TON] [float] NULL,
  [SVETLOTA] [float] NULL,
  [NASISHENOST] [float] NULL,
```

...

As you can see from the main SOIL_INDICATE table, each of the fields in the database contains information about a specific soil indicator and has its own unique name and definition type.

It should also be noted that some soil indicators from the main table have a connection with auxiliary tables, which provide a complete description of this parameter [8]. As is known, soils can retain the variable nature of soil materials, outputting from this field to the main table indicating the MATERIAL indicator, which has a connection with the auxiliary table MATERIALTYPE, which includes the names of all types of soil materials viewed in the soil definition algorithm.

Script of auxiliary table:

```
CREATE TABLE [dbo].[MATERIALTYPE]
  [IDMATERIAL] [nchar](10) NOT NULL,
  [Organic_material] [nvarchar](50) NULL,
  [Ice] [nchar](10) NULL,
  [Dense rock] [nchar](10) NULL,
  [Dense man_made material] [nchar](10) NULL,
  [Mineral material] [nchar](10) NULL,
  [Volcanic_glass] [nchar](10) NULL,
  [No_dense_rock_layer] [nchar](10) NULL
```

Developing the Soil Diagnostic Algorithm

When examining the soil group identifier key in the World Reference Base for Soil Resources, it was found that the description of RSGs is given in three different ways:

- 1) based only on certain soil parameters, e.g., the HISTOSOLS Reference Soil Group (Fig. 1);
- 2) based on soil parameters and diagnostic horizons, e.g., the ANTHROSOLS Reference Soil Group;
- 3) based only on diagnostic horizons, e.g., the UMBRISOLS Reference Soil Group.

On the basis of these three variants, we propose respective soil diagnostic algorithms based on the structure of the first level soil parameter database.



Fig. 1. Soil profile of HISTOSOLS

In the following, we describe a functional algorithm for soil identification based directly on soil parameters. We will describe this algorithm on the example of the HISTOSOLS Reference Soil Group [9, p. 95, 10]. The structure of this soil group belongs to the first of the variants described above. To identify a soil as a member of the HISTOSOLS group, it is sufficient to consider the following soil parameters:

- soil thickness (MOSHNOST);
- type of material in the soil (MATERIALTYPE);
- soil depth (QLUBINA);
- residual moss in the soil (OSTATOKMXA).

The database structure is proposed in such a way that it is possible to store the values of these parameters. Namely, the soil thickness parameter takes the value specified in the MOSHNOST field from the primary SOIL_INDICATE table in the database structure. The MATERIALTYPE soil parameter determines the type of material in the soil. The value of this parameter is displayed in the primary table in the MATERIAL field, which takes its value from the MATERIALTYPE auxiliary table in the form of the following numbers:

- 1 – organic material;
- 2 – ice;
- 3 – technic hard material.

The soil parameter indicating soil depth is determined by the QLUBINA field in the primary table of the database structure. In the HISTOSOLS Reference Soil Group, this parameter takes a value between 40 and 100 cm, or ≥ 60 cm but there must be residual moss in the soil. The parameter indicating the presence of residual moss takes the value determined by the OSTATOKMXA field in the primary table.

If all the above conditions are met, the soil can be allocated to the HISTOSOLS group with respect to the first level of the identifier key to the WRB Reference Soil Groups. The described algorithm can be given by schematically as Fig. 2.

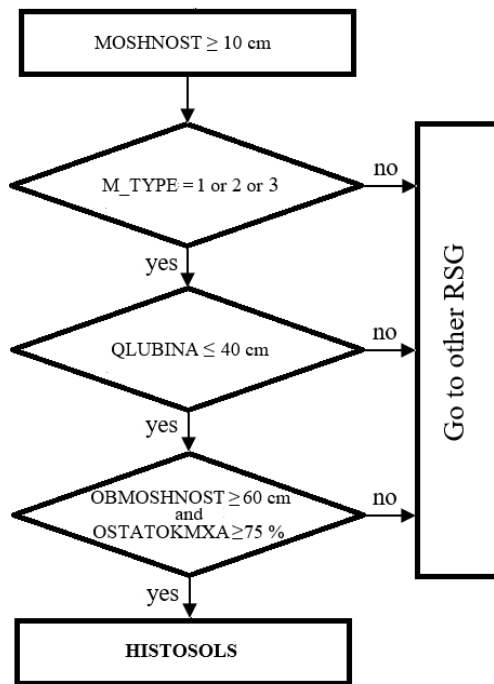


Fig. 2. Block scheme of algorithm for definition of Histosols

And also this described algorithm can be given in the form of a functional module in an algorithmic language (Pascal) [11]:

```

Function Histosols;
begin
if ((MOSHNOST>=10) and ((MATERIALTYPE=1 or
MATERIALTYPE=2 or MATERIALTYPE=3)) then
if (QLUBINA>=40 or QLUBINA<=100) or
((QLUBINA>=60) and (OSTATOKMXA>=75)) then
true;
else false;
end;

```

This function returns true if the soil belongs to the Histosols group, false if the soil does not belong to the Histosols group. Thus, the described algorithm makes it possible to identify Reference Soil Groups based directly on soil parameters.

Consider the description of the functional algorithm for soil identification by soil parameters and diagnostic horizons. We will describe this variant of the algorithm on the example of the Anthrosols reference soil group [4; p.96]. For this purpose, all diagnostic horizons included in this group were analyzed: hortic, irragric, plaggic, terric, anthraquic, hydragric, pretic. To identify a soil as belonging to the Anthrosols group, we propose determining the parameters according to the above diagnostic horizons. The hortic horizon in the soil is examined for the following parameters:

- horizon position in the soil (UP_HORIZONT)
- type of material in the soil (MATERIALTYPE)
- Munsell color value, or lightness of soil color, (SVETLOTA)
- Munsell chroma, or saturation of soil color (NASISHENNOST)
- soil condition (SOSTOYANIYE)
- soil organic carbon (ORGUGLEROD)
- extractable P2O5 content (OBMENP2O5)

- soil mechanical composition (MEXSOSTAV)
- depth (QLUBINA)
- base saturation (BASESATUR)
- horizon thickness (MOSHNOST)
- signs of soil animal activity (PRIZNAKD_J).

The parameter indicating the horizon position in the soil take the value specified in the UP_HORIZONT field of the Soil_Indicate primary table in the database structure. The MATERIALTYPE soil parameter takes a value similar to the first variant of the algorithm. Parameters determining the Munsell color value and chroma, and soil condition take their values from the SVETLOTA, NASISHENOST, and SOSTOYAN_POC fields of the Soil_Indicate primary table, respectively. In the hortic horizon the SVETLOTA and NASISHENOST parameters should be ≤ 3 , provided that the SOSTOYAN_POC parameter takes the value 1, moist. The soil organic carbon parameter takes the value from the ORGUGLEROD field and should be $>1\%$ in the hortic horizon. The content of extractable P2O5 corresponds to the OBMENP2O5 field of the "Soil_Indicate" primary table and should take a value of $\geq 100 \text{ mg} \cdot \text{kg}^{-1}$ with the depth, "QLUBINA", taking the value equal to 25 cm and the mechanical composition of the soil, "MEXSOSTAV", taking the value corresponding to fine earth. The base saturation parameter in this horizon takes its value from the BASESATUR field of the Soil_Indicate primary table and should be $\geq 50\%$. Along with these soil parameters, the algorithm also checks the thickness, MOSHNOST, of the horizon and the traces of soil animal activity, PRIZNAKD_J. Both of these parameters take their values from the MOSHNOST and PRIZNAKD_J fields of the Soil_Indicate primary table, respectively. The thickness should be $\geq 20 \text{ cm}$, and the signs of soil animal activity by volume should be $\geq 25\%$. The described algorithm of the hortic diagnostic horizon can be given in the form of a functional module in an algorithmic language (Pascal):

```

Function h88ortic
begin
if (UP_HORIZONT=1) and
(MATERIALTYPE=5) and (SVETLOTA<=3) and
(NASISHENOST<=3) and (SOSTOYAN_POC=1) and
(ORGUGLEROD>=1) and (OBMENP2O5>=100) and
(MEXSOSTAV=2) and (QLUBINA<=25) and
(BASESATUR>=50) and (MOSHNOST>=20) and
(PRIZNAKD_J>=25)
then true
else false;
end;

```

Similarly described the parameters of the irragric horizon:

- horizon position in the soil (UP_HORIZONT);
- type of horizon in the soil (ANTROPOQEN) и (MINERAL);
- structure of the horizon in the soil (STRUKTUR);
- mechanical composition (MEXSOSTAV);
- soil organic carbon (ORGUGLEROD);
- signs of soil animal activity (PRIZNAKD_J);
- horizon thickness (MOSHNOST).

The parameters of types ANTROPOQEN and MINERAL in this soil horizon take the value similarly as

in the database structure of previous algorithm. The soil parameter, which determines the structure of the soil, takes the verbal value "uniformly" from the auxiliary table STRUKTUR. The other parameters are determined by the following algorithm following these different values: soil organic carbon. ORGUGLEROD in irrigric horizon not must be low than 0.5%; soil mechanical composition MEXSOSTAV taking the value corresponding to "3", this means, that this type of soil includes clay and horizon thickness not must be low than 20 cm. The described algorithm of the irrigric diagnostic horizon can be given in the form of a functional module in an algorithmic language (Pascal):

```
Function irrigric
begin
if (ANTROPOQEN=1), and (MINERAL=1) and
  (UP_HORIZONT=1) and (STRUKTUR=1) and
  (MEXSOSTAV=1) and (ORGUGLEROD>=0,5) and
  (PRIZNAKD_J <25) and (MOSHNOST>=20)
then true;
else false;
end;
```

Then consider the soil parameters of the horizon plaggic:

- type of horizon (ANTROPOQEN and MINERAL);
- horizon position in the soil (UP_HORIZONT);
- Munsell color value, or lightness of soil color (SVETLOTA);
- soil condition (SOSTOYANIYE);
- soil organic carbon (ORGUGLEROD);
- soil texture (QRANUMSOST);
- artefakts (ARTEFAKTS);
- base saturation (BASESATUR);
- horizon thickness (MOSHNOST);
- colour of soil horizon (CVET).

The main soil parameters that are considered, when diagnostic soils in this horizon are its type and position in the soil layer. Parameter UP_HORIZONT determines its top position in the layer, and the ANTROPOQEN parameter specified in the main table determines its anthropogenicity. Some of the above parameters for this horizon are determined similarly to the previous algorithm, but with different values. For example, Parameters determining the Munsell color value and chroma of SVETLOTA takes value ≤ 4 with parameter of soil condition SOSTOYANIYE=1, and it means that soil condition is "wet", or this parameter must be ≤ 5 with SOSTOYANIYE=0 and it means that soil condition is "dry". Parameter of soil organic carbon ORGUGLEROD $\geq 0,6\%$ in this soil horizon. The MINERAL_H parameter means that the field in the main table indicates that this horizon takes the value "mineral. Parameter of soil texture is displayed in the primary table in the QRANUMS field which takes its value from the QRANUMSOST in the auxiliary table form of the following numbers: 1 – sandy; 2 – loamy; 3 – clay 4 – combined composition from sandy, silt and clay.

In this horizon, this parameter can take one of four values, so it can be "sandy," "loamy," "clay," or have a combined composition. The ARTEFAKTS parameter indicates the presence of artifact inclusions. The soil parameter BASESATUR is responsible for the degree of

soil base saturation and takes a value less than 50 for this horizon. The parameter MOSHNOST, as in the previous algorithm, takes an integer value and should be greater than 20 cm. The field of the soil parameter CVET is specified in the main table and is linked to the auxiliary table, where this parameter can take textual values such as "brown," "black," clayey color, and other colors, as well as the original material. In this horizon, this parameter should take the value of the first field, i.e., "brown" or "black." Let's present the diagnostic algorithm for the plaggic horizon in the form of a functional module in a hypothetical algorithmic language (Pascal):

```
Function plaggic
begin
if (ANTROPOQEN=1) and (MINERAL=1) and
  (UP_HORIZONT=1) and (QRANUMSOST=1) or
  (QRANUMSOST=2) or (QRANUMSOST=3) or
  (QRANUMSOST=4) and (ARTEFAKTS=1) and
  (SVETLOTA $\leq$ 4) and (SOSTOYANIYE=1) or
  (SVETLOTA $\leq$ 5) and (SOSTOYANIYE=0) and
  (ORGUGLEROD $\geq$ 6) and (BASESATUR<50) and
  (MOSHNOST $\geq$ 20) and (CVET=1)
then true
else false;
end;
```

Let's consider and describe the algorithm for the soil parameters of the "terrific" horizon:

- horizon position in the soil
- type of material in the soil (MATERIALTYPE);
- colour of soil horizon (CVET);
- base saturation (BASESATUR);
- horizon thickness (MOSHNOST);
- artefakts (ARTEFAKTS);
- pH level in the soil horizon (PhVODN);
- biological activity (BIOAKTIV).

As can be seen from the description of the algorithm for this horizon, the soil parameters UP_HORIZONT and ARTEFAKTS take the same values as the previous horizon, unlike the parameter BASESATUR. In this horizon, BASESATUR takes a value greater than or equal to 50%. The MATERIALTYPE parameter takes its value from the auxiliary table in the field labeled "5," which means "mineral material." The soil parameter CVET takes its value from the auxiliary table in the field labeled "4." This means that the soil color in this horizon depends on the original material. The PhVODN parameter takes value from the main table and in this horizon should be above 7. The parameter indicating the degree of biological activity is determined by the BIOAKTIV field from the main table. The described diagnostic algorithm for the terrific horizon can be presented as a functional module in a hypothetical algorithmic language (Pascal):

```
Function terrific
begin
if (UP_HORIZONT=1) and (MATERIALTYPE=5) and
  (CVET=4) and (BASESATUR $\geq$ 50) and
  (MOSHNOST $\geq$ 20) and (ARTEFAKTS=1) and
  (BIOAKTIV =1) and (PhVODN>7.0)
then true
else false;
end;
```

Then consider and describe the algorithm for the soil parameters of the "anthraquic" horizon:

- horizon position in the soil (UP_HORIZONT);
- type of material in the soil (MATERIALTYPE);
- soil condition (SOSTOYANIYE);
- soil color hue (TON);
- Munsell color value, or lightness of soil color (SVETLOTA);
- Munsell chroma, or saturation of soil color (NASIWENOST);
- Structure of soil (STRUKTUR);
- Cutans in soil horizon (CUTANI);
- horizon thickness (MOSHNOST).

Soil parameters such as UP_HORIZONT, MATERIALTYPE, SOSTOYANIYE, SVETLOTA, and MOSHNOST are determined in a similar way as in the previous horizon but with different values. For instance, MATERIALTYPE=5 indicates the presence of mineral material in the soil. SOSTOYANIYE, SVETLOTA, and NASISHENOST similarly take their values from the respective fields in the main database table. For example, when SOSTOYANIYE=2 and NASISHENOST<2, SVETLOTA should be less than 4 on the Munsell Scale. The parameter in this horizon can take one of the specified values: 7.5YR, GY, B, or BG. The "soil structure" parameter takes its value from the STRUKTUR field of the main table, linked to the auxiliary table STRUKTUR. It can take various values; some of them are listed as follows: 1 – uniformly; 2 – loose; 3 – blocky; 4 – crumb; 5 – columnar; 6 – granular; 7 – massive. In this case, the soil structure can take one of two values: either 6 or 7. Thus, the soil structure in this horizon can have values "granular" or "massive." The presence of cutans in this horizon is confirmed by checking the field named CUTANI in the main table, which takes the value "Bit" (0=no; 1=yes). The parameter MOSHNOST is considered in the same way as in the previous algorithm, but in this horizon, it must have a value greater than 15 cm. The described algorithm for diagnosing the anthraquic horizon can be presented in the form of a functional module in a hypothetical algorithmic language (Pascal):

```
Function anthraquic
begin
if
(UP_HORIZONT=1) and (MATERIALTYPE=5) and
(SOSTOYANIYE=1) and (TON=7.5) and
(SVETLOTA≤4) and (NASIWENOST≤2) and
((TON=B) or (TON=GY) or (TON= BG)) and
(SVETLOTA≤4) and ((STRUKTUR=7) or
(STRUKTUR=6)) and (CUTANI=1) and
(MOSHNOST≥15)
then true;
else false;
end;
```

Then consider and describe the algorithm for the soil parameters of the hydragric horizon:

- horizon position in the soil (PODPOVERX_H);
- type of material in the soil (MATERIALTYPE);
- Cutans in soil horizon (CUTANI);
- Munsell color value, or lightness of soil color (SVETLOTA);
- Munsell chroma, or saturation of soil color (NASIWENOST);
- soil condition (SOSTOYANIYE);

- Presence of iron or magnesium cementation (STYAGA);
- horizon thickness (MOSHNOST).

Some of the listed parameters are determined similarly to the descriptions of the first three horizons, albeit with different values. For example, the parameter MATERIALTYPE is determined similarly to the algorithm for the first horizon and takes the value number "5," which signifies the presence of mineral material. The presence of cutans in the mentioned horizon is also determined as described in the algorithm for the anthraquic horizon. In the hydragric horizon, the soil parameter SVETLOTA should have a value greater than 4 when the NASIWENOST parameter is less than 2. The parameter indicating the soil condition is determined in a similar manner and takes the value SOSTOYANIYE=1, signifying a wet soil condition. The next parameter indicating cementation in the soil is determined by the field STYAGA and takes a value of ≥ 5 when the MOSHNOST parameter, determining the thickness of the horizon in this algorithm description, is greater than 10 cm. The diagnostic algorithm for the hydragric horizon can be presented as a functional module in a hypothetical algorithmic language (Pascal):

```
Function hydragric
begin
if (PODPOVERX_H=1) and (ANTROPOQEN=1) and
(MATERIALTYPE=5) and (CUTANI=1) or
(SVETLOTA≥4) and (NASIWENOST≤2) and
(SOSTOYANIYE=1) or (STYAGA≥5) and
(MOSHNOST≥10)
then true
else false
end;
```

And now describe the algorithm for diagnosing the last horizon of the referential soil group ANTHROSOLS, called pretic, based on its soil parameters. Provide the specific soil parameters and criteria that should be used to diagnose the pretic horizon:

- horizon position in the soil (UP_HORIZONT);
- type of material in the soil (MATERIALTYPE);
- colour of soil horizon (CVET);
- aretefakts (ARTEFAKTS);
- Munsell color value, or lightness of soil color (SVETLOTA);
- Munsell chroma, or saturation of soil color (NASIWENOST);
- soil condition (SOSTOYANIYE);
- soil organic carbon (ORGUGLEROD);
- exchangeable magnesium content (OBMENMG);
- exchangeable calcium content (OBMENCA);
- phosphorus content (PHOSFOR).

The algorithm description for this horizon begins with checking a soil parameter indicating its location within the soil layer. This parameter is determined by the field UP_HORIZONT in the main database table and takes the value 'Bit.' The MATERIALTYPE parameter is determined and takes a value according to the previously described algorithm. Soil parameters CVET and ARTEFAKTS are determined in a similar way as described in the algorithm for the plaggic horizon. In this horizon, the SVETLOTA parameter should be less than 4, NASISHENOST should take a value less than 3 according to the soil condition parameter SOSTOYANIYE, which takes the value '1 - wet

condition.' The 'organic carbon content in the soil' parameter takes a value in the ORGUGLEROD field and, as in the plaggic horizon, should be greater than 1%. The described diagnostic algorithm for the pretic horizon can be represented as a functional module in a hypothetical algorithmic language (Pascal):

```
Function pretic
begin
if (UP_HORIZONT=1) and (MATERIALTYPE=5) and
  (CVET=1) and (ARTEFAKTS=1) and (SVETLOTA≤4)
  and (NASISHENOST≤3) and (SOSTOYANIYE=1)
  and (ORGUGLEROD≥1) and
  (OBMENMG+OBMENCA>=2) and (PHOSFOR≥30)
then true;
else false;
end;
```

The algorithms above are for determining soil parameters for each of the diagnostic horizons that belong to the ANTROSOLS group. And this algorithm can be given in the similarly block scheme as in Histosols. As mentioned earlier, some soil groups, including the ANTROSOLS group, are defined based on both soil parameters and diagnostic horizons. To obtain the final result of identifying the soil's belonging to this group, let's present the algorithm.

```
Function antrosols;
begin
if ((Hortic or iraglik or plagic or terric) and (moshnost
  >50)) or ((anthraquic or hydragric) and (moshnost
  >50)) or ((pretic and (moshnost >50) and (qlubina ≤
  100)
then true;
else false;
end;
```

The algorithm for identifying soil membership based on a combination of soil parameters and diagnostic horizons has been described. We proceed to the construction of the third variant of the algorithm, namely allocating a soil to a group based only on diagnostic horizons, on the example of the UMBRISOLS soil group [4; p.114]. In this case, parameters of the following diagnostic horizons are considered:

- umbric;
- mollic;
- hortic.

As can be seen, most of the above parameters of these horizons are determined similarly to the previous algorithm but take different values. Diagnostic algorithms were developed for each of these horizons. We will examine and describe the algorithm of soil parameters of one of the above-mentioned horizons, the umbric horizon:

- horizon position in the soil (UP_HORIZONT)
- type of material in the soil (MATERIALTYPE)
- horizon color (CVET);
- presence of artefacts (ARTEFAKTS);
- Munsell color value (SVETLOTA)
- Munsell chroma (NASIWENOST)
- soil condition (SOSTOYANIYE)
- soil organic carbon content (ORGUGLEROD)
- particle-size distribution (QLANUMSOST)
- base saturation (BASESATUR)
- horizon structure (STRUKTUR);
- extractable P₂O₅ content (OBMENP₂O₅);
- horizon thickness (MOSHNOST).

As can be seen, most of the above parameters of this horizon are determined similarly to the previous algorithm, while taking different values. For instance, the soil organic carbon parameter should take a value ≥ 0.6 %. Color in this horizon is one of the main parameters identifying a soil as belonging to this group and takes the text value "brown". The values of the SVETLOTA and NASIWENOST parameters in this horizon depend on the parameter indicating soil condition, SOSTOYANIYE. If the SOSTOYANIYE parameter takes a value equal to 1, moist, then the SVETLOTA parameter will take a value of ≤ 3 , otherwise it takes a value of ≤ 5 . The NASIWENOST parameter will take a value ≤ 3 with the value of the SOSTOYANIYE parameter equal to 1, moist. The ORGUGLEROD parameter will take a similar value as in the plaggic horizon. Base saturation of the soil, BASESATUR, takes a value of $< 50\%$ for this horizon. The most part of the umbric horizon has acidic reaction, which results in the acidity parameter, OBMENP₂O₅, taking a value of < 5.5 . Horizon thickness is determined by the MOSHNOST field and takes a value of ≥ 20 cm. And this algorithm can be given in the similarly block scheme as in Histosols. The following is the diagnostic algorithm of the umbric diagnostic horizon in the form of a functional module in an algorithmic language (Pascal):

```
Function umbric
begin
if
  ((UP_HORIZONT=1) and (MATERIALTYPE=5) and
  (CVET=1) and (ORGUGLEROD≥0.6) and
  (ARTEFAKTS=1) and (SVETLOTA≤3) and
  (NASIWENOST≤3) and (SOSTOYANIYE=1) or
  ((SVETLOTA≤5) and (SOSTOYANIYE=0))) or
  ((QLANUMSOST=3) and (SVETLOTA≤5) and
  (NASIWENOST≤3) and (ORGUGLEROD≥2.5)) and
  (BASESATUR ≤50) and (OBMENP2O5 ≤5.5) and
  (MOSHNOST≥10) or (MOSHNOST≥20)
then true;
else false;
end;
```

Parameters of the next horizon of this group, the mollic horizon, take values similar to those of the umbric horizon. The algorithm of identifying a soil for this horizon is built similarly to the previous one. The only difference is the value of the BASESATUR parameter, which in this horizon takes a value of ≥ 50 %. The final result of this variant is that when allocating soils to this group, the parameters should satisfy the values of one of these horizons. The algorithm for determining whether the soil belongs to the hortic horizon was described earlier in the second variant. The described algorithm makes it possible to identify Reference Soil Groups directly on the basis of three diagnostic horizons.

Thus, we have developed an algorithm for soil identification according to the first level of soil allocation to WRB Reference Soil Groups. Three different variants of allocating soils to WRB Reference Soil Groups have been considered.

Conclusion

Soil identification according to the World Reference Base for Soil Resources (WRB) is investigated. A structure of the database of soil

parameters of diagnostic horizons is proposed. A soil diagnostic algorithm is developed, which will allow identifying any soil type with the corresponding WRB Reference Soil Group.

Three variants of allocating soils to WRB Reference Soil Groups based only on soil parameters, or on the combination of diagnostic horizons and soil parameters, or only on diagnostic horizons are considered.

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Побудова алгоритму діагностики для ідентифікації ґрунту за міжнародною системою ґрунтової класифікації WRB

С. А. Хасанова

Анотація. Актуальність. У цій статті розглядається ідентифікація обґрунтувань для міжнародної класифікації обґрунтувань World Reference Base for Soil Resources system (WRB). Всесвітня довідкова база обґрунтованих ресурсів була розроблена для ідентифікації обґрунтувань і використання отриманих даних у різних сферах повсякденного життя: сільському господарстві, лісівництві, тваринництві тощо. **Метою роботи.** Зверніть увагу, що WRB, розроблений групою ґрунтознавців, не призначений для заміни національних систем класифікації. різні системи класифікації, міжнародні також різні класифікації обґрунтувань, розроблені національними школами ґрунтознавства. Різниця в структурах цих класифікацій зумовила необхідність розробки діагностичного алгоритму їх співвіднесення між собою. **Розглянуто.** Три варіанти визначення належності обґрунтування до еталонної групи обґрунтувань залежно або лише від параметрів обґрунтування, або від комбінації діагностичних горизонтів і параметрів обґрунтування, або лише від діагностичних горизонтів. Група вчених на чолі з М. Бабасвим також розробила національну систему класифікації підстав Азербайджану. Для порівняння цих двох систем у цьому дослідженні пропонується структура даних ґрунту, а також алгоритм ідентифікації ґрунту відповідно до класифікації WRB на основі запропонованої структури. **Висновок** Розроблено алгоритм обґрунтованої діагностики, який дозволяє ідентифікувати будь-який тип обґрунтування з відповідною еталонною обґрунтованою групою WRB. Розглянуто три варіанти віднесення обґрунтувань до еталонних обґрунтувань групи WRB лише за параметрами обґрунтування, або за поєднанням діагностичних горизонтів і параметрів обґрунтування, або лише за горизонтами діагностики.

Ключові слова: діагностичні алгоритми; структура бази даних; ідентифікація ґрунту; сольові групи; діагностичні параметри.