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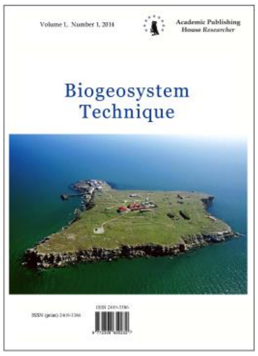


**How Healthy are Our Vegetables? Contours of a New Fertilizing Paradigm. Minerals and non Protein Nitrogen in Vegetables, Grown Organically and Respectively Conventionally. A Quality Assessment (Review)**

Anton O. Nigten [a, *]

[a] Salt of the Earth, Wageningen, Netherlands

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**Abstract**

The last hundred and fifty years food and fodder scientists did a lot of – mostly forgotten – balance studies. As a general rule we can say that the ratios of potassium, calcium, sodium, phosphor and magnesium should not be too wide. The more one of these elements dominates in food and fodder the higher the health risks. The health authorities see only the risks of too much sodium. They negate the risks of too much potassium in vegetables and too much calcium and (added) phosphate in a.o. dairy products and meat. For the correct regulation of many processes in our bodies we need much more magnesium. A further complication is that we assimilate too much ammonium and nitrate through our food, and too little trace elements.

This situation is partly brought about by the way we fertilize our crops. Most farmers – conventional and organic – have learnt that plants need in the first place nitrogen, potassium and phosphor. And some extra calcium for a good pH. Corrections for other elements are only necessary if the plants give visible signs of shortages. Part of the fertilizing theory is that organic nitrogen from plant residuals or animal dung must 'mineralize' into ammonium and nitrate before plants can take up the nitrogen. Also the other elements must be anions and cations before the plants can take them up.There is little attention for the role of the symbiontic microbes in the rhizosphere and at the other parts of the plants. And the risks of nitrate and ammonium for plant health and human health are taken as part of the game.

This view on plant feeding is a mechanistic one, dominated by chemistry and physics. Biology is missing. Although this paradigm is still the dominant one, we see the contours of a new paradigm, in which the plants and their symbionts regulate their own feeding, their own growth. With the help of their symbionts around their roots and on their leaves and stems the plants take up from the soil or the air what they need: organic nitrogen; organic sulphur, and metals and non metals connected with carbon – not inorganic ions. The symbionts in the cells help to built up or break down complex organic compounds. All enzymatic reactions are performed by living entities in and around the cells. And we know: without (trace) elements no enzymatic reactions. Magnesium is responsible for at least 600 enzymatic reactions. Zinc for 400.

* Corresponding author
E-mail addresses: aonigten@hotmail.com (A.O. Nigten)

If we look at the conventional and organic products we see that the balance is lacking, and the amount of nitrate and ammonium is high. Only the products which are fertilized with a.o. sea minerals (Normandy, 1869) are better in balance than the products today. The data on ammonium and nitrate in this period are not available. Even today we normally don't measure ammonium and nitrate in our food. And only a few trace elements…

**Keywords:** plants, fertilizing, vegetables, food, organic paradigm.

## 1. Introduction

Human beings and animals become sick when their food is not in balance. But they don't become sick and die in one or two weeks. It takes sometimes years to become sick from food which is not in balance. But the proces of getting ill accelerates if our food is more out of balance. If, for instance, potassium would be completely lacking in someone's food, he or she would problably die within weeks. Especially if we get much too little magnesium our health is at risk. Magnesium is a key element for our health, and very low in most foods. In order to understand why many organic products and even much more the conventional products are not in balance and have such a high amount of nitrate and ammonium (non protein nitrogen or NPN*) I give a characterisation of the two fertilizing systems which we have today in many parts of the World. And I finish this part with an overview of the building blocks for a new fertilization paradigm.

## 2. Quality criteria

I will start with the quality criteria which I have found during the last ten years.

These criteria result to a great extend from the findings of colleagues (Table 1).

**Table 1**. Quality criteria for food

| Ratios in the combined daily food and fodder | optima | Regulation of: |
|---|---|---|
| Potassium/Sodium | 2–5 (max 7) | Acid base balance; water retention; blood pressure (with the help of magnesium) (Bunge, 1874). |
| Potassium/magnesium | 2–5 (max 7) | Uptake of magnesium; Electrolyte balance; citric acid cycle; energy production; protein,carbohydrate and fat metabolism; impulse conduction; |
| Calcium/Magnesium | 1–2 | Uptake of calcium; regulation of calcium metabolism; bone health; (de)calcification of the weak tissues; electrolyte balance; health of the hearth, and of cells (cancer); |
| Calcium/Phosphor | 1–2 | Rickets; bone health; (de)calcification of bones and weak tissues; Stone formation; fertility; kidney disturbances; |
| Mg/(K+Na+Ca+P) | 0.15–0.25 min 0.10 | Magnesium is necessary for electrolyte balance; energy production; impulse conduction; protein,carbohydrate and fat metabolism; for K/Na balance; Ca/Mg balance; Ca/P balance; breakdown of proteins, carbohydrate and fats; prevention of stone formation; health of vital organs (brains; hearth; liver; kidney; pancreas; stomach); the immune system; prevention of depression; aggression regulation; prevention of cancer; removal of heavy metals and fluorine; 600 enzymes are magnesium dependent; |
| K/(Ca+Mg) in mEq | < 2–2.2 | This measure is developed to see if cows are at risc of grass tetany. Tetany is a neurological disorder and has many traits in common with for example epilepsy in humans. |

* In fact NPN is more than ammonium and nitrate, but the other NPN compounds – amides, amines, and others – are never measured.

| | | |
|---|---|---|
| nitrate | < 2.1–3.5 g/kg ds | McCreery et al., 1966 'the 0.21 % to 0.35 % [is the] lower limit for toxicity to ruminants'. High levels of nitrate plus potassium cause the nitrate potassium syndrome (Swerczek, 2002, 2007). |
| sulphur | < 2–3 g/kg ds | (Olson Rutz, 2014; Crawford, 2012) Many diseases are caused by too high levels of sulphur, for instance strokes (Kobayashi, 1957). |

### 3. The conventional fertilization paradigm

In conventional farming there are different approaches. And the differences between some of them are big. For instance the work of Albrecht and his followers is a reaction against the potassium dominance among the cations when it comes to fertilizing (Albrecht, 1938). Albrecht developed a theory about a necessary balance between the cations at the clay complex. Today Nutri-tech solutions which have its base in Australia have worked out this theory and are selling lots of products in order to rebalance the soils. These products are used to reach nutrient rich crops with a high brix index. Their focus is on soil balance. Not on crop balance (Nutri-tech solutions, 2019).

In this paper I focus myself on the classic NPK paradigm as it is learnt in many agricultural universities, high schools and secondary schools (Mengel, 1978; Rinsema, 1981).

The dominant conventional NPK paradigm for fertilizing is built on the following assumptions:

- The plant roots take their mineral nutrients and nitrogen from the soil. But in the 19th century many leading agricultural scientists were of the opinion that plants in nature take their nitrogen from the air. But in agriculture extra ammonium is necessary via the soil according to Lawes and Gilbert. Lawes and Gilbert had a heated debate on this issue with von Liebig (Lawes and Gilbert, 1856). Schanderl solved the problem in 1947. He has proven that, like the leguminous plants, also non leguminous plants need a certain amount of nitrogen from the soil to build up themselves, before they are able to take nitrogen from the air. Some non leguminous plants get even more nitrogen from the air than leguminous plants (Schanderl, 1947);
- In the soil moisture the minerals and inorganic nitrogen compounds are split in ions, and the plants take up these ions from the soil moisture;
- Clay particles and humus give new ions into the soil moisture if the soil water is emptied by the plant roots;
- Most plants thrive well in a soil with a pH between 5.5 and 6.5. When the soil becomes too acid the farmer has to give (lots of) calcium carbonate;
- The plants are able to take up the needed ions selectively from the soil moisture;
- The plants take up the necessary carbonic acid and oxygen from the air. In the ninetheenth century some agricultural scientists, among whom Baron Liebig, still were of the opinion that the plants took all their nitrogen also from the air (Lawes and Gilbert, 1856).
- Already in the same period Lawes and Gilbert concluded also that only roughly 40 percent of the given nitrogen was recovered in the crops. And the remainder was not found back the next year in the soil (Lawes, Gilbert, 1856: 484, 485). See annex 3.
- If one or more elements are not available in the soil moisture the plants can't thrive well. By adding the missing elements the problem is solved.
- And there are some exceptions on these rules: a too high level of potassium hinders the uptake of calcium, sodium and magnesium; high levels of potassium and nitrogen hinder the uptake of silicium; high levels of nitrogen results in watery plants and less vitamin C; high levels of calcium and phosphor hinders the uptake of magnesium (Farmer Verschoor J.: *"After 40 years of fertilization with broiler dung the soil was full of calcium and phosphor. The magnesium uptake was blocked",* verbal communication).
- In fact there are many more exceptions and with the help of Mulder (Mulder, 2019) a farmer can find out which elements block or hinder other elements, and which elements support

the uptake of other elements (see annex 1). But ... with the help of Mulder's Chart farming becomes a rather complicated question;

- Compacted soils have to be opened or broken with all kinds of machinery;
- Sodium is not really an important plant food; and silicium is also neglected. But today there is a really very interesting debate going on regarding sodium (Kronzucker, 2013). And Epstein has recently done research regarding the role of silicium in plants and he demonstrated its defensive role in biotic and abiotic stress (Epstein, 2009);
- Plants become sick because insects, nematodes, and micro-organisms attack them. In this view farming is like a poker game: sometimes you are Lucky, sometimes not;
- Fertilizing too much is not really an issue. The fertilizer industries push farmers to use hughe amounts of potassium, nitrogen and phosphor far beyond the necessary levels;
- The soil itself is not a source of fertility for the crops, but only a place to stay afoot, and a storeroom for nutrients from outside. The scientists who have shown that many important nutrients are available as minerals – true minerals – are ignored (Kahn, 2013; van Baren, 1934);
- Today the new focus is on the genes. The idea is that the genes are a pool of fairly constant characteristics. And today the way plant and animal breeders change the gene pools is by genetic modification. Most plant and animal breeders are not interested in epigenetic factors which influence the working of the genes. Plant and animal genes are in their view a kind of building bucket. The role of the scientists is to remove bad building blocks for good building blocks. The question why some building blocks become 'bad' is for these people not a research item. Their view on genetics is also a static view. Weak plants have to be made strong by an outside force – human beings who think their work is rocket science (Green breeding program, 2019).

In fact this paradigm is **a paradigm of chemistry and physics as the basis of plant nutrition**. **Not biology**. Plants have to grow on dead inorganic materials, and their natural enemies have to be killed with pesticides, also dead material, in order to protect the crops from being destroyed. The germ theory of Pasteur is at its basis (Pasteur, 1878). The germs come from outside, so a farmer has to prevent their arrival. Béchamp who focussed on the environment, was his opponent. See Douglas Hume (1932). Kate Raines gives in 2018 a very clear overview of the controverse (Raines, 2018).

The classic NPK paradigm is rooted in the mainstream of western science. In this view all natural phenomenons are mechanical phenomenons, as in the philosophy of de Lamettrie (Lamettrie, 2007). And if the machinery is malfunctioning, it is the superior intelligence of the scientist which is needed to correct the errors. Liebig was an exponent of this type of thinking.

### 4. The dominant organic fertilization paradigm

Although there are many differences between different organic farmers and their organisations, and between scientists who do research in the field of organic farming, here I focus myself on what I call **the dominant organic fertilization paradigm**. The differences between the dominant organic fertilization paradigm and the Bio-dynamic agriculture (Pfeiffer, 2011; Steiner 1924), or the "organisch biologischen Landwirtschap" of Rusch and Müller in Switserland and Austria (Rusch, 1968), the approach of Fukuoka in Japan (Fukuoka, 1978) or No Tillage in Germany (Zikeli, 2017), the work of Lutzenberger and Primavesi in Brasil (with today a strong focus on agro-ecology and agroforestry) (Lutzenberger, 1995; 1998), and the new developments in India (vermicomposts, Sinha, 2009; Chaudhuri, 2016) are **not** my focus in this paragraph. I focus on the dominant organic paradigm.

The dominant organic paradigm has some extra rules and new insights above those of the conventional agriculture:

- Soil life is indispensable for healthy plants. They create an open structure which is necessary for a good exchange of gases;
- Mycorrhiza's help the plants to get more phosphor;
- Enough organic matter is necessary for keeping enough water in the topsoil;
- In order to make a good fertilizer from farm yard manure and plant residuals you have to built piles which become warm enough, in order to kill the weed seeds and the pathogens; these heaps must be heated till 60–65 °C. Then you have to open them and mix them in order to cool down the heap and the proces starts again. Some schools repeat this opening and mixing more

often than others (for example: the CMC* method (Diver, 2004). Many organic farmers don't compost their farm yard manure at all.

- And the slurry from the basements is also spread without any treatment in many organic dairy farms in the Netherlands (but not in Biodynamic organic agriculture). In the Netherlands the injection of the slurry in the soils is legally required.

- Most 'organic' scientists still think that plants feed themselves with inorganic elements from the soil moisture, like their conventional colleagues. Complex nitrogen compounds must be broken down into nitrate or ammonia before the plants can take them up: mineralisation. The same for the other elements. Just like their conventional colleagues they think that plants can't take up more complex organic compounds. Most of these 'organic scientists' are still addicted to NPK, and the mineralisation theory.

- And today in the Netherlands 'organic' scientists also focus on genetic engineering to get stronger crops with better characteristics. Genetic engineering in the classic way, with modern means (Lammerts van Bueren, verbal communication).

Many organic and conventional farmers are experimenting with new methods:

- They add rock flour or lava flour;
- They spread seaminerals with or without NaCl;
- They ferment their farm yard manure and/or plant residuals;
- They use effective micro-organisms;
- They use (vermi)compost teas;
- They use worms in order to open solid soils;
- They use mixtures of 15–20 green manures for soil recovery;
- Some fertilize their crops with dead grasses, clover or other plant materials on top of the soil;
- Some don't plough their fields;
- Some keep their fields under a permanent green cover;
- Some farmers experiment with different sowing systems: e.g. 10 – 15 kg of wheat seeds pro hectare. All the wheat plants get ample room (Steendijk – verbal communication; Stoop, 2017);
- Some make composts between 15–35 °C;
- Some grow crops in hydrophonics on algae.

The dominant organic agriculture is still a mixture of the inorganic conventional building blocks and some organic elements. Many spokesman – sir Howard (Howard, 1943); lady Balfour (Balfour, 1977) and J.R. Rodale (Rodale, 1978) thought that this was enough for a new paradigm. And as a consequence they thought this approach was good enough to grow healthy plants, and with these healthy plants to get healthy animals and healthy men. Which is not always the case.

Although, it is a fantastic improvement that this organic agriculture doesn't use synthetic pesticides, and almost no artificial tertilizers (Patent kali is still permitted and used).

In the Netherlands we see that scientists in organic agriculture today think that it is impossible to get crops with a natural resistance which are strong enough to stay healthy. This primary presumption (Howard, 1943; Balfour, 1977; Rodale, 1978) is abandoned. And they use tricks to solve the problems of lack of natural resistance: e.g. genetic improvements. They use new genes from wild varieties in order to restore the natural resistance of the (weakened) plants. For instance: potatoes. Or they select lupine varieties which can grow on soils which are rich in calcium. Lupines can't grow on clay soils rich in lime, they think (Green breeding program, 2019).

## 5. A new emerging fertilization pardigm

In my view we are entering a third stage in agriculture. And in fact – a new stage in organic agriculture. We can say a true 'organic' organic agriculture. Let me explain this by means of some examples of the new building blocks which we need for this new paradigm. Building blocks which were developed sometimes more than 100 to 160 years ago. Sometimes by farmers, sometimes by scientist or by consultants and concerned citizens. And, very interesting, sometimes by medical doctors:

* CMC means controlled microbial composting and is delevoped in Austria by Luebke.

- Virtanen and Schreiner found out that plants can take up organic nitrogen e.g. amino acids. And according to Schreiner amino acids are possibly a better plant food than inorganic nitrogen (Virtanen, Linkola, 1946; Schreiner, 1912);
- Schreiner detected also many poisonous compounds from plant residuals if the topsoil didn't have enough oxygen during the breakdown of organic residuals (Schreiner, 1913). Many of these compounds retard the growth of young plants. Krasil'nikov came to the same conclusion but didn't analyse which growth inhibiting compounds were formed (Krasil'nikov, 1958);
- Krasil'nikov cited many scientists who found out that plants can take up organic metallic compounds;
- According to Khan and Mulvany most soils contain enough potassium for thousands of years (Khan, 2013). Potassium chloride is in their view a very risky fertilizer. Van Baren concluded already in 1934 that in the Netherlands many soils had enough potassium from true minerals for good yields. On these soils there was in his view no need to give extra potassium. Potassium salts weaken the cereals by blocking the uptake of silicium (Van Baren, 1934).
- Stoklasa and Schanderl and many others have proven that also non leguminous plants, like buckwheat, potatoes and wheat, can take nitrogen from the air, like George Ville and many others in the 19$^{th}$ century had found out already (Schanderl, 1947; Roschach, 1960; Ville, 1854). But these crops need more start nitrogen from the soil than the leguminous plants;
- Mycorrhiza brings the plants organic nitrogen compounds as wel as other nutrients (Hood, 1993);
- Many clayish soils contain enough phosphor (from apatite) for years for most crops, especially if all the residuals are brought back carefully. For sandy soils the return of the phosphor in the sewage sludge, the plant residuals, the bones and the farm yard manure is still unmissable. For most crops a closed cycle for most of the macro elements is sufficient for ever lasting harvests. Sodium and trace elements is another question. According to the findings of Bowen sodium is one of the first cations which rinses out from the soils (the Bowens reaction series, 2019). Okay, this is the physical approach. But when the earth worms can do their work the picture changes dramatically. Sir Howard (1947) calculated that earth worms deposit 25 tons of castings per acre, and the castings contain 5 times more nitrogen, and 7 times more phosphor than the 6 inch top layer (see annex 2). With vermicomposts (some?) soils can be converted from a loamy sand soil into a sandy clay soil within two years. The underlying process is unknown (Chaudhuri, 2016). But if the amounts of castings earth worms can bring up into the top layer are correct, then we can understand that sandy soils can change into more clayish soils.The worms can bring the clay from down under or they make the clay by grinding the sand and loam. And also that there is possibly enough nitrogen and phosphor from 'somewhere' if the earthworms can do their work. The best food for earth worms is provided by litter layer worms like eisenia fetida; eisenia andrei or eudrillus euginius (Chaudhuri, 2016);
- Hanspeter Rusch developed the theory that bacteria can fall apart in smaller living entities which play a crucial role in maintaining the vitality of plants and other higher organisms (Rusch, 1968). The observations of G. Enderlein (Enderlein, 1925; Krämer, 2012) and Naessens (Bird, 1991) support this theory.

Problaby Rusch founded these ideas on the work of Antoine Béchamp, the french opponent of Pasteur. But Rusch (1968) never mentions his work.

- And more recently Thomas Pradeu has proven the existence of small living entities in the cells of higher organisms which in his view are essential for the vitality of the higher organisms (Pradeu, 2016). Already between 1850–1908 A. Béchamp developed the theory that small microzymas live in the cells of higher organisms and produce enzymas (Béchamp, 1912). According to Béchamp these microzymas in the cells of higher organisms become first vibrions and then bacteria when the symbiosis between these microzymas and their host, the cells of the higher organisms, is disturbed. For instance by changing circumstances.
- Sinha has proven that vermicompost made from a good wormfeeding – for instance cow dung – gives a better compost than warm composts or untreated farm yard manure (Sinha, 2009). Farm yard manure and warm compost loose a lot of nitrogen, phosphor, potassium and carbon during heating. The same happens in slurry basements. When anaerobic rotting bacteria dominate the slurry there are big losses of ammonia; fosfine ($PH_3$) ; hydrogen sulfide; hydrogen chloride; methane and cyanide (Vanhoof P., verbal communication). Hans Peter Rusch came to

the same conclusion: warm composts and 'classic' farm yard manure are inferior compared to fertilizing the fields with fresh manures and plant residuals on the surface of the soils. Higher organisms in the topsoil, including worms, break down these materials with the help of bacteria and fungi. These bacteria and fungi themselves are eaten by other bacteria and fungi. In the end the bacteria and fungi fall apart and their residuals, including the microzymas, are the new organic plant foods (Rusch, 1968). In a living soil these foods are stored in/on humic and fulvic acids (and problably many other humic substances), combined with clay particles;

- In doing so Rusch and his farmers found out that all soils get a pH around 7 within a few years. Without adding calcium carbonate. This is opposing the ideas of Albrecht (1938) that farmers have to balance their soils with – mostly – huge amounts of calcium. Albrecht promoted the idea that a balance of potassium, sodium, calcium, magnesium and $H^+$ in the soil is necessary (Kopittke, 2007);
- Murray did a lot of trials with the fertilizing of crops with sea solids. In one trial is proven that oat and corn, fertilizied with sea minerals, are a superior food. When these cereals were given to C3H mice they didn't get cancer – 100% remained free of cancer. In the contol group all mice died of cancer (Voss, 2010);
- Reinau proved that the plants get also carbonic acid from the soil. They grow better on soil- and airy carbonic acid than on carbonic acid from the air alone (Reinau, 1927). This is in line with the findings of Lundegardh (Lundegardh, 1924);
- According to Callahan (Callahan, 1995) plants can take mineral elements from the air with their leaf hairs. He calls them leaf antennas;
- In the classic biodynamic agriculture composts were made by mixing farm yard manure, plant residuals and earth. One third each. Then compost preparations were added. Some farmers in the Netherlands did already for years the same (the socalled 'toemaken', adding soil on the manure heap).
- Bowditch found out that ammonium is bound to aluminium silicate (clay particles) and iron, and advised the farmers to use earth in order to keep the ammonium in their dung heaps, and to prevent rotting (Bowditch, 1856);
- Mineralists (geologists) have shown that the amount of true minerals in the soil is rapidly vanishing through modern agriculture, especially through nitrogen fertilizers (Bergsma, verbal communication), or potassium fertilizers (Pius Floris, Presentation, May the 25th 2018 Lunteren, the Netherlands, 2018). We call potassium a mineral, but it is an element. Feldspar, apatite and biotite e.g. are minerals;
- Sodium helps, at least in some crops, to bring down the high amounts of potassium. In a field trial in Wales, UK, the optimum dose was 173 kg salt (NaCl) per hectare. With this dose the grass was almost complete in balance for its macro elements potassium, sodium calcium and magnesium.The cows were fond of these grasses (Chiy et al., 1995). According to Voisin these salt fertilized grasses had also more vitamin A (Voisin, 1963). In fact we have to find out if sodium also can or should have a role in the non halophytic plants. And if, how to fertilize these crops with sodium without causing damage to these crops or the (clay)soils;
- High amounts of potassium and nitrate salts hinder the uptake of silicium. The stems of cereals become weaker as a consequence of lack of silicium. Cereals with long stems had to be substituted by short stem varieties (Van Baren, 1934);
- Farmers and their counsellors are experimenting in the Netherlands with special clays which bind the ammonium and other poisonous materials in the fodders. The health of the cows improves quickly (Vriezinga W, verbal communication). Giving foods with enough silicium would problably do the same.

Rhizosphere bacteria and fungi live in symbiosis with the plants. They offer each other many services on a basis of mutuality. Bacteriophages on the slimey surfaces of the roots prevent – probably – the entering of the bacteria into the plants*. And my hypothesis is that after the eating of rhizosphere microbes by the bacteriophages, the tiny microbial entities which are freed by this process, can enter the plant roots.They are problably the 'small entities' which according to Hans

* I suppose this is correct for plantroots, analog with the role of bacteriophages in the intestines of mammals (Barr, 2013).

Peter Rusch help to maintain the health and vitality of the higher organisms. According to Pradeu they live inside the cells of the higher organisms as adapted viruses (or viroids) (Pradeu, 2016). Béchamp named them microzymas.

- Silt and rock flour: fertilizing with silt or rock flour gives crops which are much more in balance than crops which are fertilized with artificial fertilizers or todays cow dung. (Herapath, 1850; Hensel, 1894). The same for seaweeds (Marchand, 1869).
- Magnesiumchloride is the most powerfull molecule for restoring our health. Magnesiumchloride is a better 'vaccin' than all the man made vaccins (Neveu, 2009). Magnesiumchloride helps to bind phosphor and ammonium in the slurry, and so prevents its evaporation (Huisman A., verbal communication);
- Magnesium prevents the forming of calciumphosphate in the weak parts of the body, like the heart, the liver, the muscles, the brain etc. Calciumphosphate is the shield of nanobacteria (Kajander et al., 1998). I suppose that magnesiumchloride prevents the formation of nanobacteria and through this the formation and precipitation of calcium phosphate (calcification). Nanobacteria can cause low-grade inflammations;
- In bones and teeth magnesium cements calcium phosphate and protects against attacks of bacteria in our mouths. The amount of magnesium in the bones and teeth is in most western countries only one fifth of the necessary amount (Barnett, 1954).

<u>Recapitulation</u>

In the nascent new paradigm plants can only be healthy if they live in perfect symbiosis with 'their' symbionts in the rhizosphere. But these symbionts live also in their cells and on their stems, leaves and fruits or seeds. These symbionts give protection and help to get the nutrients from the soil, the water and the air in the right amounts, the good forms, at the right time. They only act if the (young) plants sent them sugars and other compounds. If the growth of the plants slows down through cold, dryness, or lack of sunshine then the production of sugars also goes down, so the rhizosphere microbes get less sugar and through this send less nutrients to the plant roots (Vanhoof, verbal communication).

The nutrients from the soil are converted into organic compounds by the symbiontic microbes before being taken up by the plants. The bacteriophages play a special role in maintaining the equilibrium of the symbiosis. They are the first protection shield of the higher organisms (Barr et al., 2013).

The inorganic salts are an inferior food for the plants. If the ions of these elements and compounds dominate in the soil moisture the plants have difficulties in the selective uptake of these materials. In our agricultural systems the plants are overloaded with inorganic potassium, phosphor, nitrate and ammonium. And sometimes also with calcium and sulphate. Then the plants don't send their sugars to the soil. So the rhizosphere bacteria and fungi are no longer able to convert all the nitrogen and sulphur compounds into amino acids and/or proteins. For this conversion into amino acids and proteins these microbes need a lot of magnesium and trace elements. Magnesium and trace elements are lacking, or are availabe but can't be taken up, because high amount of potassium prevents this. A possible role of sodium in the formation of proteins has never been studied. Nor a possible role in protecting the lactic acid bacteria through sodium as in sour crout.

If plants have high levels of potassium, NPN and NPS, they become sick (Chaboussouh, 2005; Lutzenberger, 1995; Swerczek, 2002, 2007). The symbiosis is weakened. And some of the symbionts can become predators for the host. The bacteriophages no longer offer the host their protection.

In our stomach lives a bacterium, Helicobacter pylorum, an epsilon proteobacterium. Normally this bacterium doesn't harm us. People with too little vitamin B12 are at risk of getting stomach ulcers by Helicobacter pylorum. Magnesium deficiency also plays a role. Magnesium deficiency and too much potassium, ammonium and nitrate are two sides of the same coin.

Potassium salts* irritate the slimey surfaces of our body, if high (Bunge, 1894: 136):

* According to Bunge, the potassium salts are no risk if eaten as a food. The risk is there when potasasium salts are given as inorganic salts – KCL - as is done today. In the Nordic countries the health authorities are really reluctant to give KCL in order to compensate for too much sodium. In he Netherlands the KCL is sold in the supermarkets as a consequence of the advices of Dutch nutrition scientists. Vegetables, fruits and potatoes today are very high in potassium.

"Die Kalisalze haben eine locale, ätzende Wirkung. Man findet die Magenschleimhaut bei Thieren, denen Kalisalze injicirt worden, stets hyperämisch [enhanced blood supply], bisweilen auch mit Ekchymosen [bruises] bedeckt.

Werden die Kalisalze in sehr concentrierter Lösung eingeführt oder gar in Pulverform — wie es in allen Vergiftungsfällen geschehen war — so kann es zur Gastritis mit tödtlichem Ausgang kommen".

Problably the same for nitrate. Nitrate in drinking water is the cause of gastric ulcers and of many cancers (Yang, 1997) unless the drinking water has enough calcium and magnesium. The same for sulphate (Kobayashi, 1957). Sulphate forms a risk for apoplexy in areas where the water has almost no calcium- and/or magnesiumcarbonate – in the North East of Japan.

Maybe here is a parallel in cancer cells: Warburg O. (1956) teached us that all cancer cells have one thing in common. These cells are no longer able to burn pyruvic acid with oxygen in the citric acid cycle. The oxydation stops.The cells survive now on fermentation and produce lots of lactic acids. Normally the citric acid cycle finds place in the mitochondrium. The mitochondria are also former proteobacteria. The mitochondria can't work properly if the cells don't get enough magnesium. Then calcium goes into the cells and this calcium goes also into the mitochondria. There it binds with phosphor and forms granules. The mitochondria calcify (Kapustin, 2011). From the studies with nanobacteria we know now that in these granules live nanobacteria which cause low grade inflammations (Kajander, 1998). Magnesium can stop these nanobacteria to grow. So if the level of magnesium in the cell is low the mitochondria become a cause of low grade inflammation ín the cell itself. And apoptosis is prohibited by the same calciumphosphate granules. The disrupted cells don't die, but become cancer cells.

It is not clear if the disruption processes in plants follow the same Lines viz calcification …

But anyway, the sick crops make the animals and human beings also sick. The imbalance between the macro elements in these crops and the high levels of nitrate, ammonium, potassium and sulphate are indications or symptoms of their being sick. In 1933 the amount of potassium, sulphur and chloride had almost doubled since 1880 (Theel, 1933).

So now we have the instruments to measure the quality of the crops of the dominant organic practise and of conventional agriculture. And we can understand when and why things go wrong.

In the following part I will show that the crops of the dominant organic agriculture are not as healthy as should be. They are not in balance and they still have too much nitrate and ammonium (the amount of non protein sulphur wasn't measured).

## 6. Quality assesment: is the quality of the contemporary organic crops really good?

First I recapitulate the data for the carrots – organic and conventional – from the study of Domagała-Świątkiewicz I. and Gąstoł M. (Domagała-Świątkiewicz, Gąstoł, 2012) (Table 2): (data on the trace elements – Cu, Fe, Zn, Mn, Sr, B are not displayed here They can be found in the study itself).

**Table 2**. Elemental composition of carrot

| Mg/kg FM of the juice | Organic carrots | Conventional carrots |
|---|---|---|
| N $NO_3$ | 11.7 | 37.6 |
| N $NH_4$ | 49.4 | 119 |
| Ca | 67.9 | 54.4 |
| K | 2369 | 2099 |
| Mg | 126 | 166 |
| P | 376 | 384 |
| S | 141 | 194 |
| Na | 346 | 423 |
| Sum of Ca to Na* | 3425.9 | 3320.4† |
| Sum of Ca to Na minus K | 1056.9 | 1221.4 |

* This is a measure for nutrient density.

† The difference is for the biggest part through higher potassium in the organic carrots.

Now we can calculate the ratios (Tables 3–7).

**Table 3**. Calculated ratios in carrot

| Ratios | Optimal ratios | Ratios in Organic carrots | Ratios in Conventional carrots |
|---|---|---|---|
| K/Na | 2–5 | 6.8 | 4.9 |
| K/Mg | 2–5 | 18.8 | 12.6 |
| Ca/Mg | 1–2 | 0.53 | 0.32 |
| Ca/P | 1–2 | 0.18 | 0.14 |
| Mg /(K+Na+P+Ca) | 0,1–0,25 (min 0,10) | 0.038 | 0.052 |
| NPN | ALAP* | 61.1 (39 %†) | 156.6 |

**Table 4**. Elemental composition of red beets

| Mg/kg FM of the juice | organic red beet | conventional red beet |
|---|---|---|
| N $NO_3$ | 229 | 846 |
| N $NH_4$ | 110 | 199 |
| Ca | 76.9 | 58.1 |
| K | 2685 | 2641 |
| Mg | 179 | 231 |
| P | 381 | 207 |
| S | 126 | 119 |
| Na | 191 | 574 |
| Sum of Ca to Na | 3638.9 | 3830.1 |
| Sum of Ca to Na minus K | 953.9 | 1189.1 |

**Table 5**. Calculated ratios in red beet

| Mg/kg FM of the juice | Optimal ratios | Ratios in Organic red beet | Ratios in Conventional red beet |
|---|---|---|---|
| K/Na | 2–5 | 14 | 4.6 |
| K/Mg | 2–5 | 15 | 11.4 |
| Ca/Mg | 1–2 | 0.42 | 0.25 |
| Ca/P | 1–2 | 0.20 | 0.28 |
| Mg /(K+Na+P+Ca) | 0.15–0.25 (min 0.10) | 0.052 | 0.064 |
| NPN | ALAP | 339 (32 %) | 1045 |

**Table 6.** Elemental composition of celery

| Mg/kg FM of the juice | Organic celery | Conventional celery |
|---|---|---|
| N $NO_3$ | 104 | 88.9 |
| N $NH_4$ | 52.5 | 126 |
| Ca | 248.8 | 129.2 |
| K | 4156 | 3863 |
| Mg | 284.8 | 264.6 |
| P | 921 | 806 |
| S | 133 | 86 |

* Should be As low As Possible (ALAP).
† = 39 % of the conventional amount.

| | | |
|---|---|---|
| Na | 154 | 242 |
| Sum of Ca to Na | 5897.6 | 5390.8 |
| Sum of Ca to Na minus K | 1741.6 | 1554.8 |

**Table 7.** Calculated ratios in celery

| Mg/kg FM of the juice | Optimal ratios | Ratios in Organic celery | Ratios in Conventional celery |
|---|---|---|---|
| K/Na | 2–5 | 26.9 | 15.9 |
| K/Mg | 2–5 | 14.6 | 14.6 |
| Ca/Mg | 1–2 | 0.87 | 0.49 |
| Ca/P | 1–2 | 0.27 | 0.16 |
| Mg /(K+Na+P+Ca) | 0.15–0.25 (min 0.10) | 0.05 | 0.052 |
| NPN | ALAP | 156.5 (72 %) | 214.9 |

Summarising of the data

In general:

1. All vegetables are out of balance;
2. All vegetables have too much NPN; in the red beets juice NPN is extremely high, especially nitrate*.
3. Potassium is in all three vegetables very high, especially in celery.
4. The sum of the nutrients (NPN excluded) is highest for celery (above all through potassium and phosphor).

The differences between organic and conventional per product:

a. **The carrot juice, organic and conventional**:

- In the conventional carrots NPN is much higher than in the organic carrots;
- In the organic carrots potassium is higher and magnesium, sodium and sulfur is much lower than in the conventional carrots.

b. **The red beet juice, organic and conventional**:

- In the conventional red beets NPN is much higher than in the organic red beets;
- In the organic red beets magnesium and sodium are much lower and phosphor much higher than in the conventional red beets.

c. **The celery juice organic and conventional**:

- NPN is again higher in the conventional celery than in the organic celery, but the difference is less extreme than in the carrots and the red beets;
- In the organic celery potassium, calcium, sulphur and phosphor are much higher than in the conventional celery and sodium is much lower; magnesium is somewhat higher in the organic celery.

**Final judgment**

For NPN all the conventional products have a worse score compared to organic. That is in line with the data form other studies: on average organic products have half the amount of nitrate of the conventional products (Heaton, 2019). But there is a lot of variation (Dangour, 2009). According to Dangour the differences in nitrate content between conventional and organic products is small. And most studies don't measure ammonia.

The figures of the study of Iwona Domagała-Świątkiewicz and Maciej Gąstoł show how important it is to measure not only N –$NO_3$ but also N-$NH_4$ (Table 8).

* In a Dutch study in 2003 the same was found for red beets. In general conventional red beets, lettuce, spinach and endive have high to very high levels of nitrate in the Netherlands, depending a.o. on the season. 21 % of all the Dutch vegetables are above the safety limit of 2.1 gram of nitrate/kg DM (Van der Schee, 2003)

**Table 8**. Forms of nitrogen in vegetables

| Vegetables | N $NO_3$ | N $NH_4$ | NPN total |
|---|---|---|---|
| Carrots organic | 11.7 | 49.4 | 61.1 |
| Carrots conventional | 37.6 | 119 | 156.6 |
| Red beet organic | 229 | 110 | 339 |
| Red beet conventional | 846 | 199 | 1045 |
| Celery organic | 104 | 52.5 | 156.5 |
| Celery conventional | 88.9 | 126 | 214.9 |
| Sum | 1317.2 | 655.9 | 1973.1 |

So N $NH_4$ is almost 50 % of N $NO_3$. And the crops contained on average 328.8 mg NPN/kg FM of the juices* (unluckily total N is not measured (or mentioned).

The organic products contained on average 344.7/3 = 114.9 N $NO_3$ and 211.9/3 = 70.6 N $NH_4$. So $NH_4$ is on average 38 % of total NPN

The conventional products contained on average 972.5/3 = 324.2 N $NO_3$ and 444/3 = 148 N $NH_4$. So $NH_4$ is on average 31 % of total NPN.

But the variation between the three crops is great.

In this study the authors measured at least N $NO_3$ and N $NH_4$, luckily. And remember, the other NPN compounds are not even measured.

So far about Nitrogen.

For all three organic products potassium is higher than in the conventional products and sodium is lower. Magnesium is lower in organic carrot juice and in organic red beet juice, but not in organic celery juice.

The greatest health risc is produced by products with a high potassium level and a high NPN level. Especially if sodium and magnesium are low. Then there is the risc of a potassium – nitrate syndrome (Swerczek, 2002, 2007).

So from these data, with the exception of NPN, we can't say that the organic products are better than the conventional products. And Ca/P is much too low for all the products, organically and conventionally. Ca/P is slightly better for organic carrots and for organic celery, but not for organic beets.

For all three products Mg /(K+Na+P+Ca) is lower for the organic ones. But the difference with conventional is almost zero for the celery juices. And I must say: some products from Dutch greenhouses have an even lower Mg /(K+Na+P+Ca) ratio. In cherry tomatoes, grown on rockwool mats, we found a Mg/(K+Na+P+Ca) ratio of 0,015 (Duijvesteijn , unpublished data).

Nevertheless, the organic products are free from pesticide residuals and low in cadmium. That's a real progress.

Both groups are far behind what are optimal ratios.

For a comparison I have given the ratios of carrots at different times and different places (Table 9). NPN wasn't measured in these carrots.

- Dutch carrots from 2017 (RIVM Nevo, 2017): raw carrots; carrots with leaves; winter carrots ;
- Carrots from three finnish farms with a lot of disease problems: (van Laarhoven, unpublished data);
- Carrots from the study of Wolff E. (1871): nr 4 is a Belgian white carrot, and nr 8 from England 'from a very well fertilized garden';
- Carrots from Normandy, analysed by Marchand, fertilized with guanodung, seaweed; herring waste and brine (Marchand, 1869);
- And finally: the carrots from Poland from above: organically and conventionally fertilized.

* (1317.2 + 655.9)/6 = 328.8.

**Table 9**. Ratios of carrots at diferent times and different places

| Ratio | Optimal ratios | Nl raw carrot | Nl carrot with leaves | Nl winter carrot | Finnland 1 | Finnland 4 | Finnland 7 |
|---|---|---|---|---|---|---|---|
| K/Na | 2–5 (max 7) | 9.8 | 12.7 | 8 | 14.47 | 22.5 | 25 |
| K/Mg | 2–5 (max 7) | 38 | 34.4 | 41 | 19.6 | 28.2 | 23.2 |
| Ca/Mg | 1–2 | 3.8 | 3.3 | 4.4 | 1.93 | 2.16 | 1.57 |
| Ca/P | 1–2 | 0.93 | 0.79 | 1 | 0.93 | 1 | 0.78 |
| Mg/ (K+Na+Ca+P) | 0.15–0.25 min 0.10 | 0.02 | 0.022 | 0.018 | 0.04 | 0.03 | 0.036 |

Continued:

| Ratio's | Optimal ratios | Wolff nr 4 | Wolff nr 8 | Marchand yellow | Marchand red. | Carrot Poland organic | carrot Poland conventional |
|---|---|---|---|---|---|---|---|
| K/Na | 2–5 (max 7 | 1.4 | 0.54 | 1.16 | 1.14 | 6.8 | 4.9 |
| K/Mg | 2–5 (max 7) | 5 | 12.8 | 6.2 | 7.4 | 18.8 | 12.6 |
| Ca/Mg | 1–2 | 2.4 | 10.6 | 2.4 | 2.6 | 0.53 | 0.32 |
| Ca/P | 1–2 | 2.13 | 1.8 | 1.35 | 1.47 | 0.18 | 0.14 |
| Mg/ (K+Na+Ca+P) | 0.15–0.25 min 0.10 | 0.083 | 0.018 | 0.063 | 0.054 | 0.038 | 0.052 |

Especially the carrots nr 4 (Wolff, 1871) and the yellow carrots (Marchand, 1869) are almost complete in balance.

**7. Conclusion**

Most products from Normandy in the period before 1880 are much more in balance than the products today in organic and conventional agriculture. The reason is the way the farmers in Normandy fertilized their crops and grassses. They ordinarily fertilized their crops with guanodung, seaweed, herring residuals and brine. These products contain lots of sodium, magnesium and trace elements.

The way in which the white Belgian carrot was fertilized (Wolff nr 4) was not mentioned by Wolff. But I found the original data of Way and Ogston in The journal of the Royal Agricultural Society of England. The white Belgian carrot was grown bij mr Huxtable. And fertilized with bones and sulphuric acid, guanodung and ash (probably wood ash). "Drilled end of april; very good crop. Collected middle of November". The soil: 'six inches of reddish mould, containing some clay; subsoil, chalk. Does not require draining. Three years in tillage" (Way, 1847: 163).

The authors of the Poland study don't give detailed information about how the three crops were fertilized. The selected crops were grown on organic and resp. conventional farms in the south and east of Poland. The organic farms were all certified. And the scientists have noted the fertilizing and other data:

" (..) crop rotation, fertilization routine, pest management and other cultural practices for each field were recorded. At harvest the total yield and an average weight of root was noted (data not presented)" (Domagała-Świątkiewicz and Gąstoł, 2012: 175).

For a definitve judgement I needed the data about the 'fertilizing routine'. But after contacting the authors I found out that these data are not available.

**References**


Albrecht, 1938 – *Albrecht W.* (1938). The Colloidal Clay Fraction of Soil as a Cultural Medium. *American Journal of Botany*.Vol. 25, No. 6 (Jun., 1938), pp. 403-407.

Balfour, 1977 – *Balfour L.* (1977). *Towards a Sustainable Agriculture – The Living Soil.* The classic text in the organic movement is an address given by the late Lady Eve Balfour to an IFOAM conference in Switzerland in 1977. Reproduced with permission from the Organic Gardening and Farming Society of Tasmania Inc © 1995, Canberra Organic Growers Society Inc.

Baren van, 1934 – *Baren F. van* (1934). "HET VOORKOMEN EN DE BETEKENIS VAN KALI-HOUDENDE MINERALEN IN NEDERLANDSE GRONDEN". Proefschrift aan de landbouw-hogeschool. (Dissertation at Wageningen Agricultural highschool).

Barnett, 1954 – *Barnett L.B.* (1954). New Concepts in Bone Healing. *Journal of Applied Nutrition*, vol. 7, pp. 318-323.

Barr et al., 2013 – *Barr J.J. et al.* (2013). Bacteriophage adhering to mucus provide a non–host-derived immunity. *PNAS,* 110(26): 10771-10776.

Béchamp, 1912 – *Béchamp A.* (1912). Selections from: *The Third Element of the Blood.* [Electronic resource]. URL: https://pdfs.semanticscholar.org/4564/373ca49d6a2394302e2d3d0929e87f482cae.pdf (date of access 2019-02-07).

Bird, 1991 – *Bird C.* (1991). The Persecution and Trial of Gaston Naessens.Published by H.J. Kramer Inc. Tiburon Ca. [Electronic resource]. URL: https://www.amazon.com/Persecution-Trial-Gaston-Naessens-Immunologically/dp/0915811308 (date of access 2019-02-07).

Bowditch, 1856 – *Bowditch W.* (1856). On the Chemical changes in the fermentation of dung. *Journal of the Royal Agricultural Society of England,* XVI: 329. London: John Murray, Albemarle Street.

Bowens reaction series, 2019 – Bowens reaction series. [Electronic resource]. URL: http://www.colby.edu/geology/ge141/Bowen's_Reaction_Series.pdf (date of access 2019-02-07).

Bunge, 1874 – *Bunge G. von* (1874). Kali-natron und Chlorgehalt der Milch. Dissertation.

Bunge, 1894 – *Bunge G. von* (1894). Lehrbuch der physiologischen und pathologischen Chemie ; in fünfundzwanzig Vorlesungen für Ärzte und Studirende. Leipzig, Vogel.

Callahan, 1995 – *Callahan Philip S.* (1995). Paramagnetism: Rediscovering Nature's Secret Force of Growth. Acres U.S.A. 128 p. [Electronic resource]. URL: https://www.goodreads.com/book/show/641117.Paramagnetism (date of access 2019-02-07).

Chaboussouh, 2005 – *Chaboussouh F.* (2005). Healthy Crops: A New Agricultural Revolution. Jon Carpenter Publishing.

Chaudhuri, 2016 – *Chaudhuri P. et al.* (2016). Effects of rubber leaf litter vermicompost on earthworm population and yield of pineapple (Ananas comosus) in West Tripura, India. *International Journal of Recycling of Organic Waste in Agriculture,* 5(2): 93-103.

Chiy et al., 1995 – *Chiy Pc. et al.* (1995). Lactational responses of grazing dairy cows to Na or K fertilization of pastures. *Annales de zootechnie, INRA/EDP Sciences,* 44(Suppl1): 370-370.

Crawford, 2012 – *Crawford G.* (2012). Beef animal health: Avoiding Mineral Toxicity in Cattle. University of Minnesota: Beef Team Extension.

Dangour, 2009 – *Dangour A.* (2009). Comparison of composition (*nutrients and other substances*) of organically and onventionally produced foodstuffs: a systematic review of the available literature. Nutrition and Public Health Intervention Research Unit London School of Hygiene & Tropical Medicine.

Diver, 2004 – *Diver S.* (2004): Controlled Microbial Composting and Humus Management: Luebke Compost. [Electronic resource]. URL: http://www.ibiblio.org/steved/Luebke/Luebke-compost2.html (date of access 2019-02-07).

Domagała-Świątkiewicz, Gąstoł, 2012 – *Domagała-Świątkiewicz I., Gąstoł M.* (2012). Comparative study on mineral content of organic and conventional carrot, celery and red beet juices. *Agricultural University in Kraków. Acta Sci. Pol., Hortorum Cultus,* 11(2): 173-183.

Douglas Hume, 1932 – *Douglas Hume E.* (1932). Bechamp or Pasteur. A lost Chapter in the History of Biology. CW Daniel Co. Londen. [Electronic resource]. URL: http://www.laleva.org/eng/2004/05/louis_pasteur_vs_antoine_bchamp_and_the_germ_theory_of_disease_causation_-_1.html (date of access 2019-02-07).

Enderlein, 1925 – *Enderlein G.* (1925). Bakterien Cyclogenie. Prolegomena zu Untersuchungen über Bau, geschlechtliche und ungeschlechtliche Fortpflanzung und Entwicklung der Bakterien. Berlijn.

Epstein, 2009 – *Epstein E.* (2009). Silicon: its manifold roles in plants. *Annals of Applied Biology,* 155: 155-160.

Fukuoka, 1978 – *Fukuoka M.* (1978). The one straw revolution: an introduction to natural farming. Toronto: Bantam, 1978.

Green breeding program, 2019 – *Green breeding program*, Wageningen University, the Netherlands (2019). [Electronic resource]. URL: www.wur.nl. (date of access 2019-02-07).

Heaton, 2019 – *Heaton S.* (2019). Organic farming, food quality and human health A review of the evidence. *Soil association.* p. 27: nitrate in organic Foods. [Electronic resource]. URL: https://www.soilassociation.org/media/4920/policy_report_2001_organic_farming_food_quality_human_health.pdf (date of access 2019-02-07).

Hensel, 1894 – *Hensel J.* (1894). Bread from Stones. A New and Rational System of Land Fertilization and Physical Regeneration. Translated from the German. A. J. Tafel. Philadelphia.

Herapath, 1850 – *Herapath Th.* (1850). The Improvement of Land by Warping, chemically considered. *Journal of the Royal Agricultural Society of Egland.* Volume the Eleventh. London: John Murray, Albemarle Street, P. 93.

Hood, 1993 – *Hood S.* (1993). Exhausted Soil Produces Exhausted People. *Acres USA*: 30, 39.

Howard, 1943 – *Howard A.* (1943). An Agricultural testament. Oxford University Press, New York and London.

Howard, 1947 – *Howard A.* (1947). The Soil and Health: A Study of Organic Agriculture. The Devin-Adair Company.

Kajander et al., 1998 – *Kajander E.O. et al.* (1998). Nanobacteria: an alternative mechanism for pathogenic intra-and extracellular calcification and stone formation. *Proc. Nat. Acad. Sci.,* 95(14): 8274-8279.

Kapustin, 2011 – *Kapustin A.* (2011). Elevated calcium and phosphate impair mitochondrial function in calcifying human vascular smooth muscle cell. Published by the BMJ Publishing Group Limited.

Khan, 2013 – *Khan S.* (2013). The potassium paradox: Implications for soil fertility, crop production and human health. *Renewable Agriculture and Food Systems,* 29(1): 3-27. DOI: 10.1017/S1742170513000318

Kline, 2013 – *Kline G.* (2013). Humus and worm castings. [Electronic resource]. URL: www.blacklakeorganic.com (date of access 2019-02-07).

Kobayashi, 1957 – *Kobayashi J.* (1957). On geographical relationship between the chemical nature of river water and death-rate from apoplexy. *Berichte d' Ohara Inst f landwirtsch Biologie,* 11: 12-21.

Kopittke, 2007 – *Kopittke P.* (2007). A Review of the Use of the Basic Cation Saturation Ratio and the "Ideal" Soil. *Soil Science Society of America Journal Abstract – REVIEW & ANALYSIS,* 71(2): 259-265.

Krämer, 2012 – *Krämer E.* (2012). Leben und Werk von Prof. Dr. Phil. Günther Enderlein. Reichl Verlag St Goar. 4e Auflage.

Krasil'nikov, 1958 – *Krasil'nikov N.* (1958). Soil microorganisms and higher plants. Academy of Sciences of the USSR Publishing, Moscow.

Kronzucker, 2013 – *Kronzucker H. et al.* (2013). Sodium as nutrient and toxicant. *Plant and Soil,* 369: 1-23.

Lamettrie de, 2007 – *Lamettrie J. de* (2007). *De mens een machine. Translation H Bakx. Boom meppel Amsterdam. English: "Man a machine". The french text "L'Homme machine" was published in 1748 in Leiden, the Netherlands.*

Lawes and Gilbert, 1856 – *Lawes J.B. and Gilbert J.H. (1856). On some points connected with agricultural chemistry. Journal of the Royal Agricultural Society of England, XXI.* [Electronic resource]. URL: https://www.biodiversitylibrary.org/bibliography/86012 (date of access 2019-02-07).

Lundegardh, 1924 – *Lundegardh H. (1924). Der kreislauf der Kohlensäure in der Natur. Verlag von Gustav Fischer.*

Lutzenberger, 1995 – *Lutzenberger J. (1995).* A Plea for Agriculture without Poisons. The Gaia foundation.

Lutzenberger, 1998 – *Lutzenberger J.* (1998). The Absurdity of Modern Agriculture – From Chemical Fertilizers and Agropoisons to Biotechnology. The Gaia Foundation.

Marchand, 1869 – *Marchand E. (1869).* Étude statistique, économique et chimique sur l'agriculture du pays de Caux. PARIS imprimerie de Madame Veuve Bouchard-Huzard, Rue De L'Eperon, 5.

McCreery et al., 1966 – *McCreery R.A., Hojjati S.M., Beaty E.R.* (1966). Nitrates in animal forage as influenced by frequency and height of clipping. *Agron. J.,* 58: 381-382.

Mengel, 1978 – *Mengel K. et al.* (1978). Principles of Plant Nutrition. International Potash Institute.

Mulder's Chart, 2019 – *Mulder's Chart*. Plant Nutrient Interactions. [Electronic resource]. URL: https://www.scribd.com/document/347630830/Mulder-s-Chart (date of access 2019-02-07).

Neveu, 2009 – *Neveu A.* (2009). Le chlorure de magnésium dans les maladies infectieuses. Editor: Sciences libres, Bordeaux.

Nutri-tech solutions, 2019 – Nutri-tech solutions [Electronic resource]. URL: www.nutri-tech.com.au. (date of access 2019-02-07).

Olson-Rutz, 2014 – *Olson-Rutz K.* (2014). Phosporus, potassium, sulfur and micronutrients. Montana State University Extension. 2014 EB0217. Department of Land Resources and Environmental Sciences.

Pasteur, 1878 – *Pasteur L.* (1878). Germ Theory and Its Applications to Medicine and Surgery. Translation: H.C.Ernst. Source: Scientific papers; physiology, medicine, surgery, geology, with introductions, notes and illustrations. New York, P. F. Collier & son [c1910]. The Harvard classics v. 38.

Pfeiffer, 2011 – *Pfeiffer E.E.* (2011). Pfeiffer's Introduction to biodynamics. Floris Books. 80 p.

Pradeu, 2016 – *Pradeu T.* (2016). Mutualistic Viruses and the Heteronomy of Life. Studies in History and Philosophy of Biological and Biomedical Sciences. [Electronic resource]. URL: http://www.sciencedirect.com/science/article/pii/S1369848616300012 (date of access 2019-02-07).

Raines, 2018 – *Raines K.* (2018). Pasteur vs Béchamp: The Germ Theory Debate. [Electronic resource]. URL: https://thevaccinereaction.org/2018/02/pasteur-vs-bechamp-the-germ-theory-debate/ (date of access 2019-02-07).

Reinau, 1927 – *Reinau P.* (1927). Praktische KohlensäureDüngung in Gärtnerei und Landwirtschaft. Berlin Verlag von Julius Springer.

Rinsema, 1981 – *Rinsema W.* (1981). Bemesting en meststoffen. Stam/Robijns BV 13$^{e}$ druk

RIVM Nevo, 2017 – *RIVM Nevo* gives data on the nutrient composition of dutch foods. [Electronic resource]. URL: https://nevo-online.rivm.nl/ (date of access 2019-02-07).

Rodale, 1978 – *Rodale J.R.* (1978). Magnesium, The Nutrient That Could Change Your Life. New York: Jove Publications.

Rusch, 1968 – *Rusch H.P.* (1968). Bodenfruchtbarkeit. Organischer Landbau Verlag.

Schanderl, 1947 – *Schanderl H.* (1947). Botanische Bakteriologie und Stickstoffhaushalt der Pflanzen auf neuer Grundlage. Stuttgart Verlag Eugen Ulmer.

Van der Schee, 2003 – *Schee H. van der.* (2003). Nitrate content of primary agricultural products of the Dutch market. De Ware(n)-Chemicus 3 (2003) 152-170.

Schreiner, 1912 – *Schreiner O.* (1912). Nitrogenous soil constituents and their bearing on soil fertility. US Department of agriculture.

Schreiner, 1913 – *Schreiner O.* (1913). Elimination and Neutralization of Toxic Soil Substances. *Proceedings of the American Philosophical Society*, 52(210): 420–430.

Sinha, 2009 – *Sinha R.* (2009). Vermiculture & sustainable agriculture. American-Eurasian. *Journal of Agricultural & Environmental Sciences.*

Steiner, 1924 – *Steiner R.* (1924). De landbouwcursus: eerste voordracht. Uitgeverij Vrij Geestesleven.

Roschach, 1960 – *Roschach H.* (1960). Die Stickstoffbilanz von Buchweizen. Zeitschrift für Pflanzenernährung, Düngung, Bodenkunde, 88(1): 18–35. [Electronic resource]. URL: https://onlinelibrary.wiley.com/doi/pdf/10.1002/jpln.19600880104 (date of access 2019-02-07).

Stoop, 2017 – *Stoop W.* (2017). Opportunities for ecological intensification: lessons and insights from the System of rice/crop intensification – their implications for agricultural research and development approaches. *CAB Reviews,* 12(036).

Swerczek, 2002 – *Swerczek T.W.* (2002). Saprotrophic Fungi and Bacteria and Commensal Bacteria that Infect Frost-Damages Pastures may be Contributing to Gut Microbial Overgrowth and Lesions Associated with the Mare Reproductive Loss Syndrome. *J. of Equine Veterinary Science,* 6: 234-237.

Swerczek, 2007 – *Swerczek T.W.* (2007): Nitrate Toxicity, Sodium Deficiency and the Grass Tetany Syndrome. Annual Growers Mineral Solutions meeting, Milan, Ohio, December, 4. rowers mineral solutions. [Electronic resource]. URL: http://www.growersmineral.com/ (date of access 2019-02-07).

Theel, 1933 – *Theel E.* (1933). Über den Mineralstoffgehalt deutscher Futtermittel. Ergebnisse an Wiesenheu. Publisher: Landwirtschaftliche Hochschule Berlin. 1933.

Ville, 1854 – *Ville G.* (1854). Absorption de l'azote de l'air par les plantes. *Comptes rendues de l'Acad. des sciences*. band 38 Paris 1854 S 705 709; 723-727.

Virtanen, Linkola, 1946 – *Virtanen AI., Linkola H.* (1946). Organic nitrogen compounds as nitrogen nutrition for higher plants. *Nature,* 158: 515.

Voisin, 1963 – *Voisin A.* (1963). Grass tetany. Charles C Thomas – Publisher Bannerstone House 301–327. East Lawrence Avenue, Springfield, Illinois, U.S.A.

Voss, 2010 – *Voss R.* (2010). Dr. Maynard Murray's Story: sea minerals cure. *Acres USA.* October.

Warburg, 1956 – *Warburg O.* (1956) On the origin of cancer cells. Science, 123(3191).

Way, 1847 – *Way J.* (1847). Report on the analysis of the ashes of plants. (Second part). *Journal of the Royal Agricultural Society of England* (VIII): 134-209.

Wolff, 1871 – *Wolff E.* (1871). Aschen-Analysen von landwirthschaftlichen. *Produkten, Fabrik-Afällen und wildwachsenden Pflanzen, 1–2*. Verlag von Wiegand und Hempel Berlin.

Yang, 1997 – *Yang C.* (1997). *Gastric Cancer Mortality and DrinkingWater Qualities in Taiwan. Arch. Environ. Contam. Toxicol.*, 33: 336-340.

Zikeli, 2017 – *Zikeli S.* (2017). Reduced Tillage and No-Till in Organic Farming Systems, Germany—Status Quo, Potentials and Challenges. *Agriculture,* 7: 35. DOI: 10.3390/agriculture7040035. [Electronic resource]. URL: www.mdpi.com/journal/agriculture (date of access 2019-02-07).

## Annex 1.

## Mulder's chart

Mulder's chart of mineral interactions – Soil Analyst Cooperative
soilanalyst.org/mulders-chart/

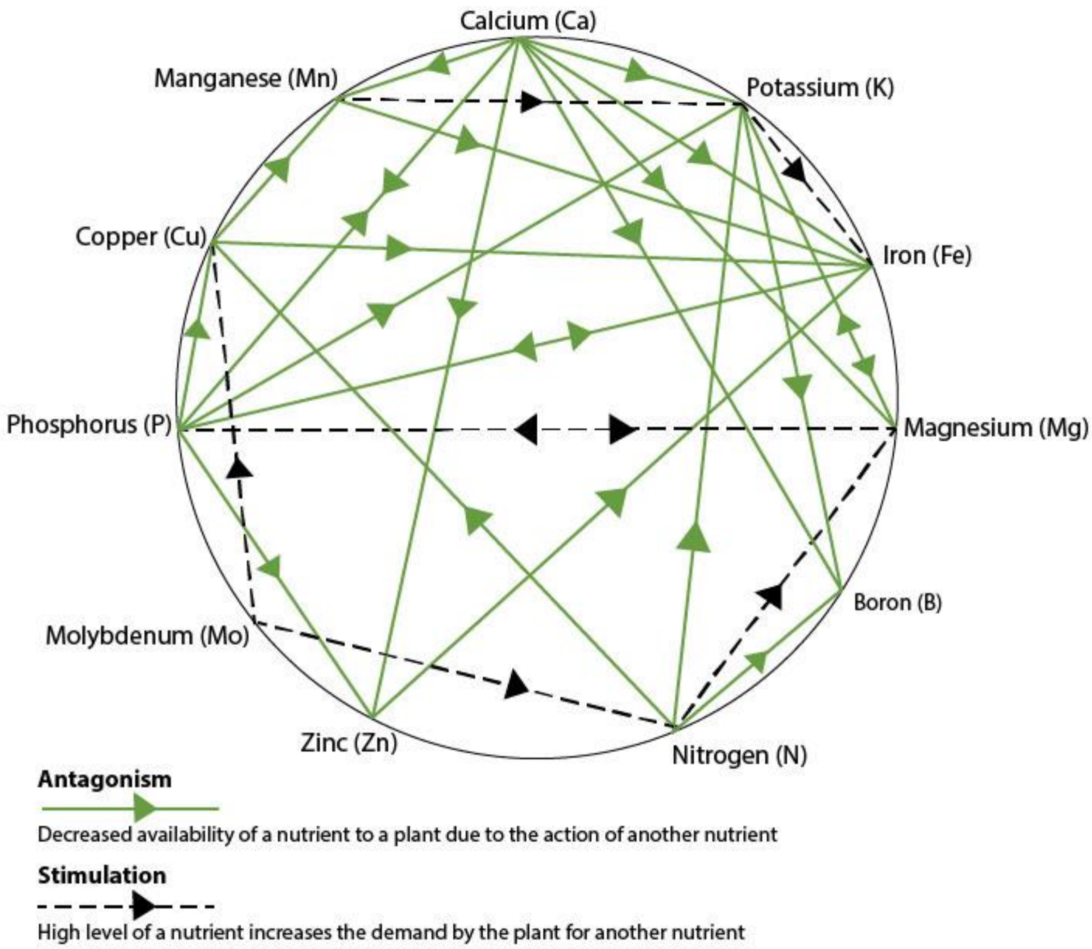
**Mulder's chart** of mineral interactions. Categories: **Mulder**, Soils and Growing, Soils General. **Chart** showing how the presence or absence of various elements influences the uptake of other elements by plants. **Mulder's chart** of nutrient interactions ...

"Antagonism

"Mulder's Chart shows some of the interactions between plant nutrients. High levels of a particular nutrient in the soil can interfere with the availability and uptake by the plant of other nutrients. Those nutrients which interfere with one another are said to be antagonistic. For example, high nitrogen levels can reduce the availability of boron, potash and copper; high phosphate levels can influence the uptake of iron, calcium potash, copper and zinc; high potash levels can reduce the availability of magnesium. Thus, unless care is taken to ensure an adequate balanced supply of all the nutrients – by the use of analysis – the application of ever higher levels of nitrogen, phosphorus and potassium in compound fertilisers can induce plant deficiencies of other essential nutrients.

Stimulation

Stimulation occurs when the high level of a particular nutrient increases the demand by the plant for another nutrient. Increased nitrogen levels create a demand for more magnesium. If more potassium is used – more manganese is required and so on. Although the cause of stimulation is different from that of antagonism, the result is the same – induced deficiencies of the crop if not supplied with a balanced diet. High levels of molybdenum in the soil and in the herbage reduce an animal's ability to absorb copper into the blood stream, and ruminant animals grazing these areas have to be fed or injected with copper to supplement their diet (see Mo/Cu dotted line)".



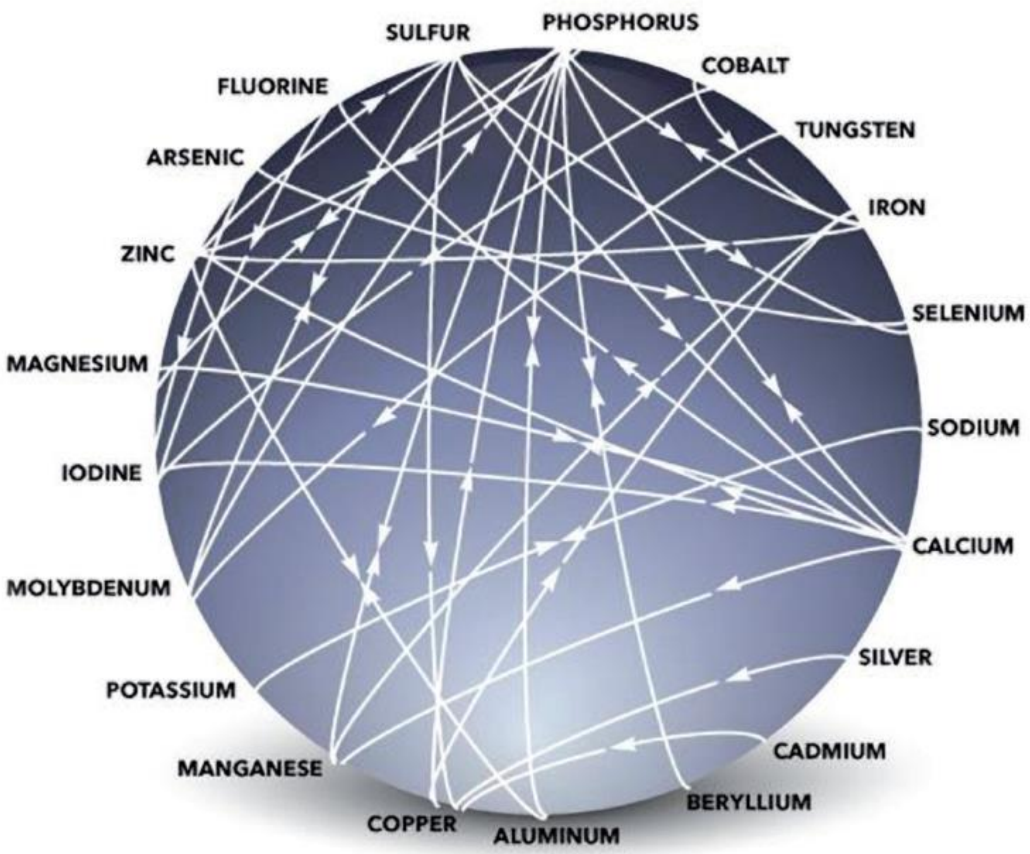

Mulder's Chart

ANTAGONISM A decrease in availability to the plant of a nutrient by the action of another nutrient (see direction of arrow).

STIMULATION – An increase in the need for a nutrient by the plant because of the increase in the level of another nutrient.

(Unluckily not all the charts of Mulder, avaible at the internet, are the same (Nigten).

Compare the next one:




At this chart there is no interaction at all between copper and molybdenum. And nitrogen is missing. And here there is no relation between potassium and iron, between potassium and magnesium, potassium and calcium, potassium and manganese, and between potassium and phosphor. Silicium is lacking on both charts. And we know that sodium promotes the uptake of calcium and magnesium (Chiy, 1995).

## Annex 2

## The role of earthworms

"(…) Here's what Sir Albert Howard, in ***Soil and Health*** (1947), had to say about the process and the make-up of [earthworm]castings:

"The casts are manufactured in the alimentary canal of the earthworm from dead vegetable matter, and particles of soil. In this passage the food of these creatures is neutralized by constant additions of carbonate of lime from the 3 pairs of calciferous glands near the gizzard, where it is finely ground prior to digestion. The casts which are left contain everything the crop needs – nitrates, phosphates, and potash [NPK] in abundance, and also in just the condition [soluble?] in which the plants can make use of them."

**Further Explanation** – Howard goes on to cite that often-mentioned analysis as follows: "Recent investigations in the United States show that the fresh casts of earthworms are 5 times richer in **available** nitrogen, 7 times richer in **available** phosphates and 11 times richer in **available** potash than in the upper 6 inches of soil." It's that word "available", in contrast with previously non-available, which explains the higher content of nutrient minerals in the castings coming out, versus the "soil" and organic matter going in. As near as I can tell, these numbers came from a single USDA study done in Connecticut in July, 1944.

**Restoration Tool** – Very large portions of the earth's soil have been eroded and exhausted over the past 5,000 years all around the world. In recent centuries the rate has been stepped-up many times the rate of natural soil formation. The earthworm potentially is a major tool (if properly fed) for restoring and rebuilding those soils. Here's further explanation from Dr. Thomas J. Barrett's 1947 and 1959 book ***Harnessing the Earthworm***:

"In the chemical and mechanical laboratory of the earthworm's intestines are combined all the processes of topsoil-building. The earthworm swallows great quantities of mineral earth with all that it contains of vegetable and animal remains, bacteria and microscopic life of soil. – – – Finally, it is ejected in and on the surface of the earth as castings – earthworm manure – humus, a crumbly, finely-conditioned topsoil, richly endowed with all the elements of plant nutrition in water-soluble form."

**In Summation –** I'm not sure that all (or most) topsoil is from worm castings which are, in turn, humus. Recall that this was the claim of Barrett and Darwin. Darwin calculated that worms deposit 10 tons of castings per acre each year. Sir Albert Howard figured it was 25 tons. In some parts of the world these deposits have been measured to far exceed those amounts. Whether or not topsoil is castings and castings are humus, or that humus requires soil and clay for its formation, the creation of 25 tons per acre or more of new topsoil per year is nothing to sneeze at. This represents a too-often overlooked means of restoring billions (yes, billions) of acres of ground lost to the plow, it's modern successors, and a century of reckless chemicalized agriculture that are soon going to be necessary to the survival of civilization. In ancient Egypt it was a crime to kill earthworms. Let's not forget the lowly earthworm. It's the least we can do". (Kline, 2013).

## Annex 3

**The loss of nitrogen in cereals** (Lawes and Gilbert, 1856: 484, 485)

"As a final average it is seen that we have, including all these cases and extending over so many years, in the case of wheat, only 39.9 per cent, and in that of barley only 43.1 per cent, of the nitrogen of the manure recovered in the increase of crop! ...and certainly the near approximation in the averages of the two crops is not a little striking; especially when we remember, that in the case of the barley there were no instances of more than standard amount of nitrogen used, which would obviously have brought down its final average nearer to that of the wheat.

Now, the final average here obtained in the case of wheat, would represent exactly 51/4 lbs. of ammonia for each bushel of grain (with its equivalent of straw), obtained by its use, assuming average proportions of corn to straw, and of nitrogen in both: and, again, by the same method of calculation, tlie return of rather more than 40 per cent, of nitrogen, the result where the standard amount of ammonia with minerals was used, would be almost identically equivalent to 5 lbs. of ammonia in manure for every bushel of corn, and its equivalent of straw, obtained as increase of crop!

So much, then, for the indications of some hundreds of direct experiments on this subject. But we further unhesitatingly maintain, that the general result here arrived at, agrees very closely indeed with that of common experience in the use of guano and other nitrogenous manures for the increased growth of grain" (Gilbert and Lawes 1856: 484, 485).

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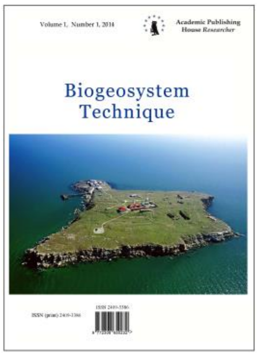


**Principles of the Soil Red Book Compilation in Vietnam and Russia**

Alla A. Okolelova [a, *], Thinh V. Nguyen [b]

[a] Volgograd State Technical University, Volgograd, Russian Federation
[b] Joint Russian–Vietnamese Tropical Scientific Research and Technological Center, Southern Branch, Ho Chi Minh City, Vietnam

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**Abstract**

There are no reliable mechanisms for preserving the diversity of the soil cover as a whole, as information about soils is dispersed among different departments, each has its own idea of the value of soil objects and ways of its preservation. The following interrelated elements are included in the soil objects "red book": 1) soils of agricultural lands; 2) soils of the system of specially protected natural areas, including soils listed in the Red book; 3) soils alienated for non-agricultural use. The following categories are proposed as tools for assessing soil productivity: optimum or well-being area, normal state area, tolerance range, extreme. The division is based on the score of soil bonitet. It is offered to allocate the high productivity soils of the agricultural land which soil bonitet value is above of the average in the administrative and land-estimation areas that will serve as a basis for the sparing land-use mode assignment.

The initiative to create the Red book of soils, the introduction of the status of "soil monument of nature" belongs to Russian scientists. But already in Vietnam too, on the basis of available protected areas for biodiversity conservation, they are working to identify the zonal soils types and assign them a status that allows to complete the monitoring of ecosystems and to protect the soil.

Southeast Asia is a region of very high diversity of flora and fauna. In Vietnam after establishing the CUC Phuong national Park in 1962 in the North of the country, a network of protected areas was created. At present, in the country there are 30 national parks, 58 nature reserves and 46 protected natural areas. In the International Union for Conservation of Nature network (IUCN) of protected areas in Indochina and Malaysia, Vietnam is characterized by the highest level of endemism (WWW, 2008; FAO, 2010).

**Keywords**: Red book of soils, Russia (Volgograd region) and Vietnam soils of agricultural lands, soils of specially protected natural areas, soils withdrawn from agricultural use.

## 1. Введение

Почва – самый консервативный и неотъемлемый элемент экосистемы, который «держит» собой все её компоненты. Экологические функции почв, их биосферную

* Corresponding author
E-mail addresses: allaokol@mail.ru (A.A. Okolelova)

значимость отразили в своих трудах еще В.В. Докучаев (Докучаев, 1994), эстафету подхватили российские ученые: Л.О. Карпачевский, (1971, Л.О. Карпачевский и др. (Карпачевский и др., 1995), В.М. Фридланд (Фридланд, 1972), В.А. Ковда (Ковда, 1981), Г.В. Добровольский с соавторами (Деградация и охрана почв, 2002; Почвы..., 2012; Добровольский, Никитин, 2000; Добровольский, Куст, 2004; Добровольский и др., 2004), О.С. Безуглова (Безуглова, 2009), Е.Д. Никитин и другие (Никитин и др., 1987), А.А. Околелова (Околелова, 2004). Необходимость охраны почв обсуждается несколько десятилетий (Охраняемые природные территории, 1991; Почвенно-экологический мониторинг, 1994).

А.И. Климентьев и Е.В. Блохин рассматривают почву как живой организм, определяют морфологию почвенного профиля как «анатомию почвенного тела», устанавливают «генетическое единство», существующее в почвенном профиле. «Каждый горизонт профиля почв «кодирует» в своей «памяти» результаты воздействия и влияние абиотических, биологических и антропогенных факторов в форме морфологических признаков и характеристик» (Климентьев, Блохин, 1996).

Генетическое разнообразие, провинциальное своеобразие, возраст и эволюция, индивидуальные черты, морфологические особенности свойственны любой почве. По мнению Г.В. Добровольского и Е.Д. Никитина, «необходимо повысить оценку значимости неживой природы до уровня живых организмов» (Добровольский, Никитин, 2000: 60). Почва – природное образование, в котором все её компоненты формируют уникальность каждой таксономической единицы.

А. И. Климентьев с соавторами (Климентьев и др., 2001: 231) считают, что «в регионах, где работа по созданию Красной книги почв налажена лучше (Оренбургская область, Калмыкия и др.) такая служба должна функционировать в первую очередь».

**2. Методология Красной книги почв**

Красная книга почв служит инструментом оконтуривания генетически наиболее значимых почв, имеющих особую ресурсную ценность, для сохранения видового разнообразия почв, в том числе и зональных типов.

Организация документа, каковым должна стать Красная книга почв, научно обоснована и закреплена законодательно. Уже созданы Красная книга почв и экосистем Калмыкии (Ташнинова, 2000, 2003), почв Оренбургской области (Климентьев, Чибилев, 1999; Климентьев и др., 2001), Ленинградской области (Апарин и др., 2007). Выделены «краснокнижные» почвенные объекты в Московской (Закон Московской области..., 1995), Брянской, Воронежской, Пензенской, Ростовской, Тюменской, Челябинской областях, в республиках Башкортастан, Татарстан, Чувашия (Закон Чувашской республики..., 2000), Красноярском крае.

Несколько десятилетий ученые исследуют почвенный покров Волгоградской области, выявлены основные причины деградации и опустынивания и меры борьбы с ними: Программа защиты... (Программа защиты..., 1993), Субрегиональная национальная программа... (Субрегиональная национальная программа..., 1999) и предложены к охране почвы Волгоградской области в трудах Дегтяревой, Жулидовой (Дегтярева, Жулидова, 1970; Почвы Волгоградской области..., 1982); Околеловой и др. (Околелова, 2004; Околелова, Егорова, 2004, 2008; Околелова и др., 2006); монографиях и отчетах: Земельные ресурсы Волгоградской области (Земельные ресурсы..., 1997, Земельные ресурсы..., 2004), Красная книга почв Волгоградской области (Красная книга..., 2017), Почвы совхоза «Трехостровской» (Почвы совхоза Трехостровской..., 1976), Почвы совхоза «Хоперский» (Почвы совхоза «Хоперский»..., 1974), Пояснительная записка... (Пояснительная записка..., 2000), Список почвенных разновидностей... (Список почвенных разновидностей..., 1988), Схема землеустройства ГУ «Природный парк «Волго-Ахтубинская пойма» (Схема землеустройства..., 2003), Технические отчеты по почвенному обследованию совхоза «Комсомолец» (Технический отчет..., 1986), совхоза «Пойменный» (Технический отчет..., 1987), совхоза «Каршевитский» (Технический отчет по почвенному..., 1987).

В качестве существенных принципов уже имеющихся документов выделим следующие два:

1. Учет провинциальных особенностей в каждом регионе. Например, черноземы обыкновенные карбонатные в Калмыкии, реликтовые почвы на фрагментарных выходах гипса кристаллического в Оренбуржье, солонцово-солончаковые комплексы, как представителей «гомологического» ряда эволюции почв в аридных условиях, типичные зональные почвы Европейской части России, целинные эталоны и освоенные почвы редких таксонов.

2. Почвенные эталоны зональных типов почв сельскохозяйственных угодий, включенные в Красную книгу, не изымают из хозяйственного использования.

Это реальное свидетельство роли такого документа, каким является Красная книга почв, в сохранении почвенного покрова, экологических функций почв.

А.И. Климентьев с соавторами предлагают вносить в Красную книгу «почвы, площади которых на территории области ограничены, сократились и продолжают сокращаться, что может привести к их полному исчезновению», они разработали следующие принципы отбора почвенных индивидуумов для занесения в Красную книгу почв (Климентьев и др., 2001: 153, 225):

1. Принцип безусловного приоритета подтипа почвы, острая необходимость его срочной государственной охраны.

2. Презумпция благополучного состояния подтипа почвы на основе объективных данных об их состоянии.

3. Региональный принцип. Почвоохранными мероприятиями должна быть охвачена вся территория, на которой распространен подтип или вид.

4. Консортивный и педоценотический принцип, ориентация на типичность, их формирование на наиболее распространенных почвообразующих породах.

Почвенный покров охраняемых территорий занимает свою уникальную нишу. Почвы естественных экосистем нуждаются в выявлении, учете и охране. В данном случае речь идет о почвенных эталонах.

За эталоны ряд ученых принимают целинные почвы заповедников, не утратившие первозданной природной связи с другими компонентами ландшафта и имеющие ненарушенный профиль О.В. Чернова (Чернова, 2002; Чернова, 2018), Чернова и др., (Чернова и др., 2003).

А.И. Климентьев (Климентьев, 2000: 414) обосновал необходимость отнесения к основным эталонам «категории зональных почв высоких таксономических уровней». Ученый и его соавторы считают возможным относить к эталонным почвы опытно-производственных хозяйств, госсортоучастков и полагают, что такие почвы могут являться эталонами высокой культуры ведения хозяйства (Климентьев и др., 2001).

В Красную книгу следует включить почвенные таксономические единицы, которые бы представляли существующее разнообразие почвенного покрова области, с учетом степени типичности, редкости, генетических особенностей, без явных признаков деградации. Это позволит сформировать своеобразный Фонд почвенно-генетического разнообразия, раздел «Почвы СООПТ», обеспечить репрезентативность почвенных объектов.

Красная книга почв – прежде всего документ, обусловливающий правовую защиту почв. «Юридически занесение почвы в Красную книгу означает для природопользователя возложение на него обязанности особой её охраны, для предприятий (независимо от форм собственности), учреждений и граждан – ответственности за незаконные распашку или освоение эталонов почв и эталонных участков», – считают ученые (Климентьев и др., 2001: 13).

Отличие Красной книги почв от таковой, созданной для растений и животных в следующем:

- континуальность почвы как природного объекта, постепенность перехода от одной разности к другой;

- отсутствие очевидной основной единицы изучения и классификации, аналогичной виду биоты;

- трудная воспроизводимость почвы как естественно-исторического образования;

- неразрывная связь с ландшафтом, в котором она сформирована.

Природоохранный смысл имеет лишь сохранение участков в пределах ареала нуждающейся в охране почвы. Красная книга почв – не просто перечень типов, а список конкретных участков их расположения.

Для Красной книги почв предложены (Чернова, 2018) две категории: естественные и ценные антропогенные и природно-антропогенные. Естественные подразделяют на:

- эталонные, куда включены основные, региональные, эталонные комбинации и почвы – объекты стационарных исследований; В качестве эталонных предлагают почвы, типичные для обширных однотипных по структуре почвенного покрова территорий;
- редкие: уникальные (редкие на территории России), редкие в регионе, антропогенно-измененные, сохранившие специфические природные особенности редких почв при отсутствии целинных аналогов;
- исчезающие подразделены на исчезающие на целине и минимально антропогенно преобразованные при отсутствии целинных аналогов.

В ценных антропогенных и природно-антропогенных почвах выделяют две группы.

1. Окультуренные, достигшие высокого уровня плодородия в результате культуры земледелия (сортоиспытательные участки и объекты многолетних исследований (опытные поля НИИ и ВУЗов).
2. Антропогенно-естественные почвы разделены на три категории: почвы курганов, древних поселений, рудников, археолого-почвенные объекты); почвы адаптивно-ландшафтных систем земледелия (древние оазисы, оросительные системы, террасированные склоны.
3. Почвы садов, огородов монастырей и усадеб и городов, старых ботанических садов.

Европейское Агентство по окружающей среде для объектов почвенного мониторинга предлагает два вида характеристик (Enviromental indicators…, 1999; Enviromental signals, 2000; Proposal…, 2001).

1. Обязательные: физико-химические, гидрофизические, физические, физико-механические и биологические свойства, а также концентрацию поллютантов.
2. Необязательные (опустынивание, подкисление, засоление содержание специфических видов организмов, эвтрофикация.

## 3. Результаты и обсуждение

3.1. Опыт охраны почвенного покрова во Вьетнаме

Инициатива создания Красной книги почв, введения статуса «почвенный памятник природы» принадлежит российским ученым. Во Вьетнаме, на основе имеющихся заповедных территорий для сохранения биоразнообразия, работают над выявлением зональных типов почв и статуса, позволяющего их сохранить для ведения мониторинга экосистем и охраны самих почв.

Юго-Восточная Азия – регион с очень высоким разнообразием флоры и фауны. Только в Индонезии насчитывают больше видов, в том числе эндемичных, чем в любой другой стране мира. За ней следуют Австралия и Китай (Groombridge, Jenkins, 2000). Факторами, в наибольшей степени ответственными за эти изменения, являются трансформирование земной поверхности, климатические изменения, загрязнение окружающей среды, неконтролируемая добыча природных ископаемых и вырубка лесов, а также интродукция экзотических видов (Sala et al., 2000). Текущая скорость видового истощения в несколько раз выше «фоновых» темпов, преобладавших на протяжении всего геологического времени (May et al., 1995).

Во Вьетнаме с возникновением национального парка Кук Фыонг в 1962 г. на севере страны, создается сеть природоохранных территорий. В настоящее время в стране существует 30 национальных парков, 58 заповедников и 46 охраняемых природных зон. В сети охраняемых природных территорий IUCN в Индокитае и Малайзии, именно Вьетнам характеризуется наиболее высоким уровнем эндемизма (WWW, 2008; FAO, 2010). В последнее время во Вьетнаме описано большое количество новых для науки видов (Dung, 1993; Forest Inventory… 1995; Le, 2009; Hämäläinen, 2014; Long-Fei et al., 2014; Park…, 2004). Это указывает на то, что состав флоры и фауны Вьетнама все еще остается белым пятном для науки. Вьетнам находится в ряду первых 15 стран, в которых велика угроза вымирания млекопитающих, среди 20 стран, в которых прогнозируют исчезновение птиц и в группе среди первых 30 стран, в которых высока опасность исчезновения растений и амфибий (IUCN, 2019).

Вьетнам занимает площадь более 33 млн. га, из них 3/4 расположены в горной и лесной местности. Почвенный покров на этой площади представлен 31 типом почв (Chan, Le, 1999; Fang 1962; Le, 2009; Soil map, 1991, 2003, 2004; Ministry of forests… 1992; Ministry of agriculture… 2013; Monitoring centre… 2012, 2013; Moorman, 1960). Во Вьетнаме изучение свойства и плодородие почв различных лесных экосистем начато в 1960 г. Основные направления:

– фундаментальные исследования: почвообразующие породы, минеральный и гранулометрический состав (Vu et al., 1963; Thai, 1964, 1970, 1972; Chan, Nguyen, 1978);

– обобщение основных свойств почв различных типов лесов на севере Вьетнама: Nguyen Ngoc Binh (Nguyen, 1996), Nguyen Quoc Thang (Nguyen, 1988), Nguyen Van Toan (Nguyen, 2010), Nguyen V.D. с соавторами (Nguyen et al., 2013);

– исследование изменения свойств и плодородия почв, их деградация и восстановления растительного покрова на севере Вьетнама (Chang, Chang, 1998; Khao et al., 1979; Ho, Kazuhico, 2001; Le, 1978, 1981a, 1981b, 1982; Le et al., 2009; Nguyen, 2010);

– исследование накоплений органических веществ в почве, свойства и состав гумуса в различных типах лесных почв (Nguyen, 1996; Do et al., 2006; Nguen, Okolelova, 2014; Ngo 1978, 1979, 1988; Ngo et al, 1991; Nguyen et al., 2013, Nguyen, Bui, 2018; Околелова и др., 2014; Stevenson, 1982; To, Nguyen, 2001; To et al., 2006).

– свойства и плодородие почв агроценозов (Pham et al., 1994, 1995, 2011; Pham et al, 2001a, 2001b; Rajendra et al., 1997; Society…2000), основных плантаций эвкалипта (Do, 1997; Do, Nguyen, 2001), сосновых лесов (Do et al., 2006) бамбуковых лесов и под фикусом, лилейных лесов в монографии Nguyen N.B. (Nguyen, 1996), мангровые лесов (Pham, 1994, 1995, 2011). В своей монографии Nguyen N.B. (Nguyen, 1996) впервые рассмотрел основные свойства почв Вьетнама под естественными первичными и мало нарушенными лесами.

Nguyen Y.S.R., Thai F. (Nguyen, Thai, 1999), Tone T.Ch., Le Th.B. (Tone, Le, 2000), Do D.S., Ngo D.K., Nguyen T.S., Nguyen N.B. (Do et al., 2006) разделили площади почв под лесами по типам и высотам:

– высота 2.000 до 3.142 м над уровнем моря, площадь составляет 280.714 га, алисоли;

– высота 600 (800 м на юге) до 1.800 (2000 м на юге) над уровнем моря, площадь более 3.503.024 га, красно-желтые гумусовые горные почвы;

– высота от 100 м до 600 м (800 на юге) над уровнем моря, площадь 20,452,000 га. В том числе, невысокие горы и холмы – 14,740,000 га; горы и базальное плато – 1,360,000 га; горы и известковые плато – 1,283,000 га и другие равнинные и полуравнинные элементы рельефа, красно-желтые ферраллитные почвы.

Исследованию ферральсолей и флювисолей Заповедника Донг Най (южный Вьетнам), почвы национального парка Кон Ка Кинь (Центральный Вьетнам) посвящены последние исследования Nguyen Van Thinh с соавторами (Nguyen, Okolelova, 2014; Nguyen et al., 2018).

Используя классификации лесных почв Вьетнама и метод FAO – UNESCO, Nguyen N.B. (Nguyen, 1996) и Do D.S. с соавторами (Do et al., 2006) разделили их на основные группы:

– *Песчаные почвы* (Arenosols). Песчаные почв и прибрежные дюны во Вьетнаме встречаются на всей территории страны с севера до юга. По данным, полученным в 2000 г., они занимают площадь, равную 562,936 га, что составляет 1.8 % общей площади страны. Для растительности характерны только некоторые виды кустарников и сорняков, например *Spinifex littoreus*, *Desmodium ovalium*, *Vitis pentagona*.

– *Пойменные засоленные почвы* (Salic Fluvisols). Почвы, сформированные на морских отложениях, в результате периодического затопления при приливахили восходящих токов минерализованных грунтовых вод в сухой сезон. Эти почвы распространены на 971,356 га. На них произрастают вечнозеленые широколиственные мангровые леса. Основные представители: семейство ризофоровые (*Rhizophora apiculatta*, *Rhizophora mucronata*, *Bruguiera sexangula*…).

– *Серные флювисоли* (Thionic Fluvisols). Локализованы на равнинных дельтах, особенно в дельте реки Меконг с тропическим муссонным климатом. Площадь группы – 1,863,128 га. Тип леса: вечнозеленые тропические мангровые леса, род Мелалеука (Melaleuca).

–*Красно-желтые ферраллитные почвы* (Ferralsols). Площадь 14,808,319 га. Почвы сформированы в условиях тропического муссонного климата на высоте от 50 м до 800 м (1,000 м) над уровнем моря. Тип леса: вечнозеленые широколиственные тропические леса. Типичными деревьями являются представители семейств Dipterocarpaceae (*Dipterocarpus alatus, D. dyeri, Hopea odorata, Shorea* sp.) и Fabaceae (*Afzelia xylocarpa, Dalbergia* sp., *Pterocarpus pedatus*).

–*Бурые тропические ликсисоли* (Lixisols). По данным общества почвоведов Вьетнама (2000) их площадь равна 42,330 га. Тип леса – тропические листопадные, представлены видами *Lagerstroemia tomentosa*, *Dipterocarpus tuberculatus*, *Dipterocarpus obtusifolius*.

–*Серые лесные почвы* (Rendzinas, Luvisols). Почвы сформированы на нейтральных магматических породах и известняках. Тип лесов: девственные хвойные *Cupresus terulsus*, *Podocarpus fleuryi* на черных почвах, сложенных на известняках; вечнозеленые широколиственные леса на бурых и буро-красных почвах на горных известняках.

–*Красно-желтые гумусные горные почвы* (Alisols). Распространены в зоне субтропического высокогорного климата. Типы лесов: субтропические, муссонные, вечнозеленые широколиственные. Площадь от 3,239,717 га до 3,503,024 га. Растительность представлена *Castsnopsis tribuloides*, *Castsnopsis fleuryi*, *Castsnopsis ferox*, *Pasania pinetti*, *Fokienia hodginsii*, *Pinus kesiya*, *Taxus chinensis*.

–*Желтоземы* (Humic Alisols) занимают площадь от 193,570 га до 280,714 га. Почвы сформированы в условиях умеренного высокогорного климата. Субтропические широколиственные и хвойные леса.

–*Эрозионные слаборазвитые каменистые почвы* (Leptosols). Площадь 505,298 га. Почвы подвержены эрозии, в результате вырубки лесов. Встречаются заросли травы и луга.

Уделено внимание изучению ферраллитных почв (Le, 1978, Le et al, 1981a). Ферраллитные почвы распространенны под лесами в горах и на холмах Вьетнама (Nguen, 1996; Do et al., 2006).

3.2. Обоснование статуса объектов «краснокнижные» почвы

Почвенный покров Волгоградской области очень пестрый, насчитывает более 35,000 таксономических единиц (Список почвенных разновидностей..., 1988). Распределение земель Волгоградской области по категориям приведено в Таблицах 1, 2, Рисунке 1.

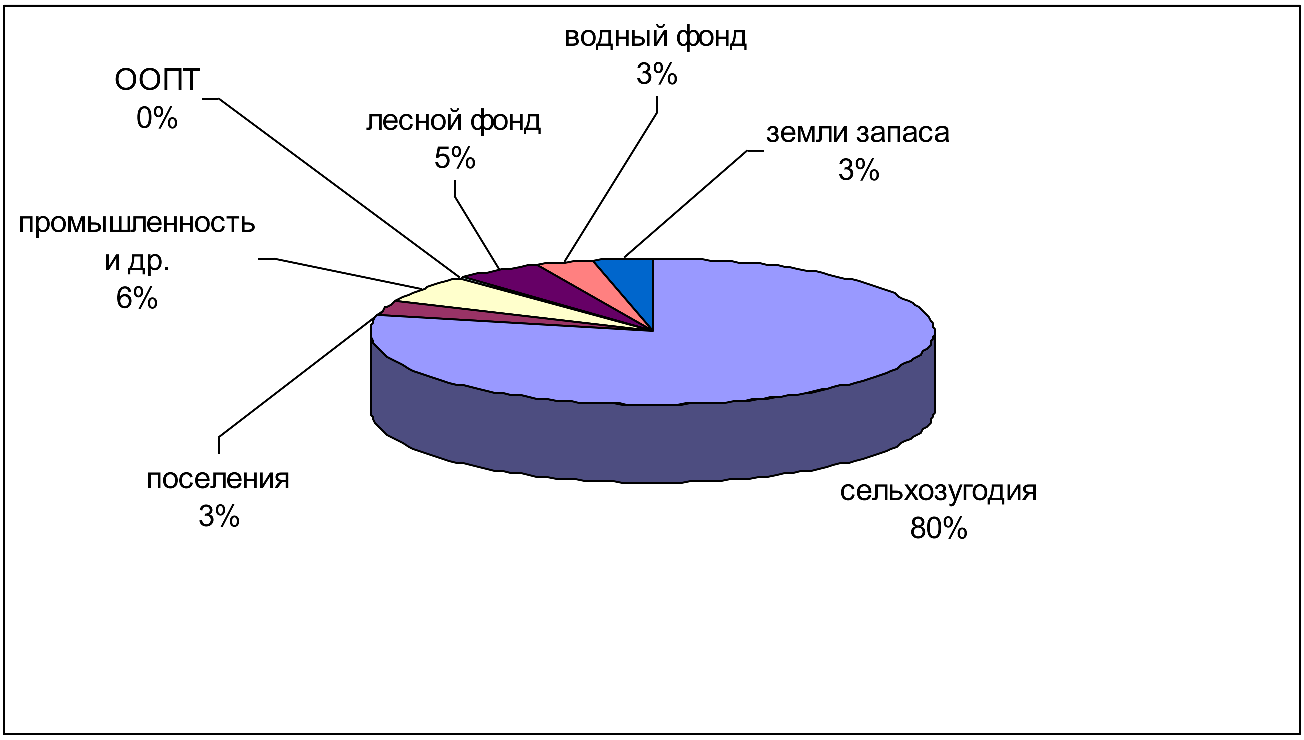



**Рис. 1.** Распределение земельного фонда Волгоградской области

**Таблица 1.** Распределение земель по категориям, га (Земельный фонд…, 2003)

| Всего | В том числе | | | | | | |
|---|---|---|---|---|---|---|---|
| | С/х назначения | Поселения | Промышленность, транспорт | Природоохранного назначения | Лесного фонда | Водного фонда | Запаса |
| 11,287,700 | 88,051 | 328,338 | 730,051 | 33,085 | 560,551 | 364,822 | 390,346 |

Согласно Таблице 1, очевидно преобладание земель сельскохозяйственных угодий на территории области. Меньше всего в области земель особо охраняемых природных территорий, их общее количество составляет всего 33,085 га, во многих районах подобная категория земель не выделена. Лишь в Палласовском районе на долю земель этого назначения приходится 31,451 га, в Среднеахтубинском – 744 га, Фроловском – 189 га, Михайловском – 140 га, Светлоярском – 91 га, Калачевском – 85 га, Городищенском – 76 га, Ленинском – 69 га. В Алексеевском, Быковском, Дубовском, Иловлинском, Камышинском, Ольховском, Серафимовичском, Урюпинском районах – от 3 до 56 га.

Основные элементы структуры земель:

1. Почвы сельскохозяйственных угодий. Для почв этого раздела предлагаем их разделение по продуктивности, которую оценивают по величине балла бонитета – ценные по продуктивности почвы, почвы со средней продуктивностью, малопродуктивные и нарушенные.

2. Почвы системы особо охраняемых природных территорий (СООПТ) в том числе и почвы, включенные в Красную книгу. В этот раздел также входят ценные по продуктивности почвы сельскохозяйственных угодий.

Кроме этого сюда включены почвенные эталоны и почвенные памятники природы, выделенные и организованные в естественных экосистемах и в объектах СООПТ.

3. Почвы, отчужденные из экосистем для несельскохозяйственных нужд. В этот раздел входят малопродуктивные почвы сельскохозяйственных угодий, рекультивированные почвы, и почвы, изъятые во временное пользование. Последние подразделяются на не подлежащие рекультивации, согласно ГОСТам, и подлежащие рекультивации.

Сельскохозяйственные угодья – основная часть почвенных ресурсов Волгоградской области (Рисунок 2). Среди них преобладает пашня (5,891,829), существенная часть которой орошается. Второе место по площади занимают пастбища, чуть меньше распространены сенокосы (Рисунок 3).

3.3. Почвы сельскохозяйственных угодий

Для почв сельскохозяйственных угодий первостепенное значение имеет их плодородие. В.Ф. Вальков с соавторами (Казеев и др., 2010: 12-13) различают две формы плодородия. «Во-первых, плодородие почвы выражается в продуктивности (урожайности) произрастающих на ней растений, в количестве синтезируемой фитомассы. Во-вторых, плодородие почв выражается в богатстве элементами питания, гумусом, в растительно-экологических свойствах и их количественно-качественных особенностях».

Эксплуатация почв сельскохозяйственных угодий должна опираться на их продуктивность. Балл бонитета – критерий, по которому выделяем категории состояния почв, оцениваем уровень плодородия, определяем их устойчивость по отношению к деградационным процессам.

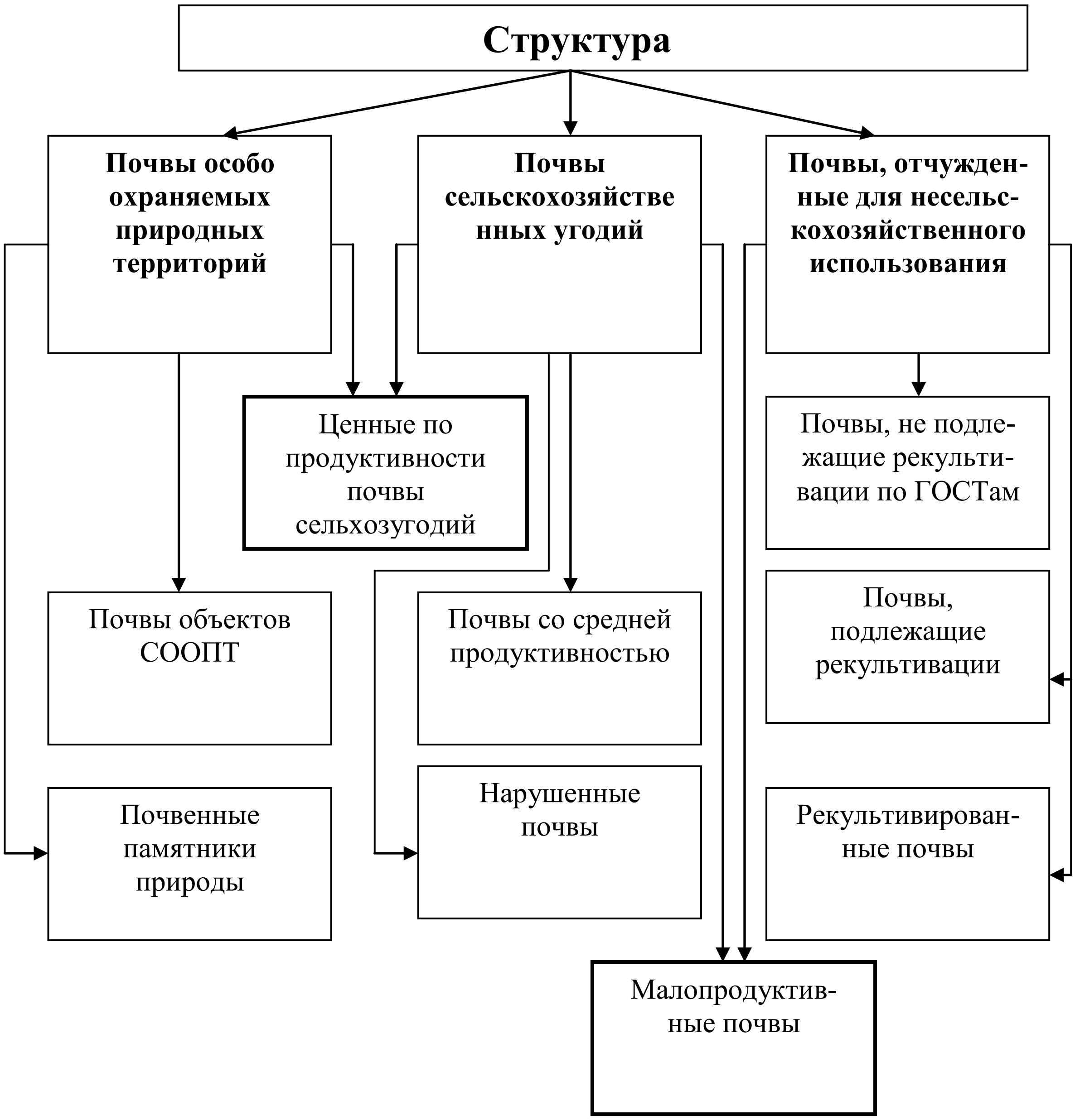



**Рис. 2.** Структура выделения «краснокнижных» почв

С учетом современной классификации почв (Классификация почв России, 2000) и кадастровой оценки земель (Методика государственной кадастровой оценки... 2000, Организация кадастрового учета... 2004) проводят оценку качества почвенного покрова. Важную роль государственной кадастровой оценки земель отметили А.И. Стифеев, Е.А. Бессонов и О.В. Никитина (Стифеев и др., 2019), указав, что она играет значительную роль в охране почв. В основе ее был и остается бонитет, оценка качества почв по баллам.

Предлагаем ориентировочную оценочную шкалу, разделяющую почвы по продуктивности на четыре категории (Таблица 2).

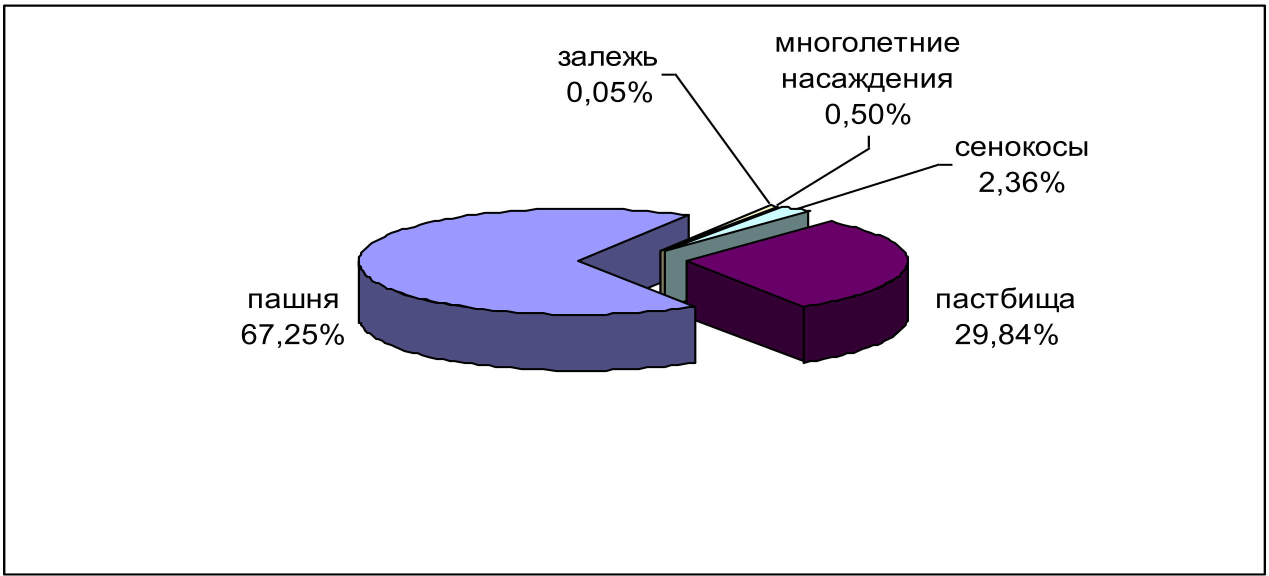



**Рис. 3.** Распределение сельскохозяйственных угодий по категориям

**Таблица 2.** Оценка состояния почвы, баллы

| Состояние почвы | Черноземы южные | Темно-каштановые |
|---|---|---|
| Оптимум, область благополучия | > 100 | > 70 |
| Область нормального существования | 80–100 | 50–70 |
| Диапазон толерантности | 50–80 | 30–50 |
| Экстремум | < 50 | < 30 |

Категория ценных почв – оптимум, область благополучия. В эту категорию входят почвы с наибольшими значениями балла бонитета, сюда можно отнести черноземы южные с баллами выше 100, темно-каштановые – с баллами выше 70.

К ценным по продуктивности почвам предлагаем относить почвы:

балл которых превышает среднее значение для соответствующего земельно-оценочного района; балл которых выше средней величины в своем административном районе;

потенциальное плодородие которых выше, чем в данном земельно-оценочном районе. Например, черноземы обыкновенные в зоне распространения каштановых почв, каштановые в зоне распространения светло-каштановых почв.

Область нормального состояния. В эту категорию отнесены почвы, продуктивность которых соответствует своим потенциальным способностям и обеспечивает прибыль при их сельскохозяйственном использовании. Сюда предлагаем включить разновидности черноземов южных, имеющие балл от 80 до 100 и темно-каштановые почвы с баллами от 50 до 70. Хозяйственная деятельность на почвах со средней продуктивностью должна быть организована в условиях щадящего режима пользования, с использованием эффективных мер мелиорации, предупреждения развития негативных процессов. Они могут служить ядрами конденсации экологического благополучия экосистем.

Диапазон толерантности. Категория почв с пониженной продуктивностью, затраты на хозяйственное использование которых убыточны. В эту область нами отнесены черноземы южные с баллами от 50 до 80, темно-каштановые почвы с баллами от 30 до 50.

В нормативных документах используют такие термины как «малопродуктивные» и «низкопродуктивные» угодья (Положение о порядке возмещения убытков..., 1999 п. 35). Но не указаны критерии выделения этих категорий. Категория «диапазон толерантности» и определяет низкую продуктивность угодий. Величина балла бонитета в данном случае – надежный способ определения категории.

Экстремум – категория почв с явными признаками деградации, черноземы южные с баллами ниже 50, темно-каштановые почвы с баллами ниже 30. В эту категорию попадают нарушенные, деградированные почвы.

Обязательным для почв с различной продуктивностью является экологическая совместимость видов их эксплуатации. Основные задачи этого раздела: сохранить плодородие ценных по продуктивности почв; восстановить функции продуктивных почв; ввести адаптивные технологии, способствующие реанимации почвенных функций на потенциально плодородных почвах с низким значением балла бонитета и явными признаками деградации; обосновать перевод малопродуктивной пашни в менее интенсивные угодья (сенокосы и пастбища, лесоразведение) и виды их мелиорации.

Четкая градация видов землепользования позволит, учитывая качество почв, позволит решить поставленные задачи.

3.4. Почвы системы особо охраняемых природных территорий (СООПТ), включая почвы, внесенные в Красную книгу почв

Для почв, как естественно-исторического объекта, создание памятников природы целесообразно и необходимо. Термин «памятник природы», предложенный в XIX веке Александром Гумбольтом не очень «ложится» на растения и животные. Как можно назвать расцветающий благоухающий цветок или резвого пушистого зверька «памятником»? Почва этому термину соответствует в достаточной степени. Почвенное разнообразие – залог формирования основного ее свойства – способности создавать условия для жизни живых организмов. Возможность сохранения естественных почвенных разностей необходима для углубленного изучения почвообразования и понимания эволюции природной среды, а также для проведения сравнительного анализа процессов, происходящих в целинных и освоенных почвах.

Исследование почв заповедных объектов позволяет оценить степень глобальности обусловливающих их процессов. В. В. Докучаев считал необходимым сохранить почвы в «нормальном первоначальном» виде, из чего и вытекает целесообразность и актуальность Красной книги почв.

«Создание почвенных заповедников (в большинстве в составе уже существующих, но в ряде случаев и специальных) имеет не только научное значение – это долг человека перед природой, перед людьми будущих поколений». В.М. Фридланд и Г.А. Буяновский предлагают выделять эталонные комплексы, к которым относят наиболее типичные и хорошо выраженные почвенные микрокомбинации – совокупность закономерно чередующихся пятен различных почв, обусловленную чередованием различных элементов микрорельефа (Фридланд, Буяновский, 1977: 117).

Разработка мер по сохранению эталонных и редких почв как среды обитания наземных организмов позволит предотвратить отрицательные явления, повысит биопродуктивность естественных экосистем и будет способствовать сохранению биосферы (Никитин, 1982; Ташнинова, 2003).

К исчезающим О.В. Чернова (Чернова, 2003) относит целинные почвы под лесостепной и степной растительностью – черноземы оподзоленные, выщелоченные, типичные, обыкновенные, южные, а также темно-каштановые и аллювиальные почвы под естественной растительностью.

Предлагая в кадастр ценных почвенных объектов почвы степной зоны Ростовской области, О.С. Безуглова (Безуглова, 2009) с соавторами обуславливает их значимость тем, что они могут служить базой для производственных и научных исследований, а также в качестве сохранения генофонда воспроизводства растений и животных.

А.И. Климентьев и Е.В. Блохин (Климентьев, Блохин, 1996: 12) считают, что «следует специально выделить типичные ландшафты для каждого региона и внести их в Красную книгу. Ведь когда-то обширные черноземные степи с ковылем и типчаком превратились в громадную пашню». В Оренбургской области А.И. Климентьев с соавторами (Климентьев и др., 2001: 11-12) выделяют местные (локальные) эталоны. К ним ученые относят почвы «разнообразные по режимам, строению и свойствам, обусловленным местными особенностями почвообразования: литологией пород, характером рельефа, гидротермическим режимом и т. д. Поиск ведется как на особо охраняемых территориях, так и на нераспаханных пастбищах и сенокосах».

Почвы СООПТ автоматически ограждены от негативного воздействия. Для этих почв также необходимо создать кадастр. Если почва сама соответствует рангу, достойному ее заповедывания, то это только повышает значимость объекта СООПТ.

Глава XVII Земельного Кодекса «Земли особо охраняемых территорий и объектов» (Земельный кодекс РФ, 2001, ст. 95, 96, 100) оговаривает их сохранение и фактически исключает изъятие земельных участков для нужд, противоречащих их целевому назначению.

Федеральный закон «Об охране окружающей среды» № 16 (199) (Федеральный закон…, 2004) содержит статью 62 «Охрана редких и находящихся под угрозой исчезновения почв». Название статьи аналогично статье 60 «Охрана редких и находящихся под угрозой исчезновения растений, животных и других организмов». Но именно этот подход к почвам и вызывает вопросы.

Определение «почвы, находящиеся под угрозой исчезновения», воспринимается как характеристика чрезвычайно деградированных почв, «потерявших» свое лицо. Если имеется в виду отчуждение локально расположенной эндемичной таксономической единицы из экосистем, то отчасти эта формулировка справедлива. Что понимается под термином «редких»? Для почвенного покрова Калмыкии черноземы обыкновенные – редкость. Но их будут беречь, охранять не из-за степени редкости, а потому, что это черноземы. Для Волгоградской области «редки» остаточно-луговые почвы. Логично предположить, что имеют в виду почвенные таксономические единицы, которые практически утрачены в своем естественном, целинном качестве.

В пункте 1 статьи 62 говорится, что «почвы подлежат охране государства, и в целях их учета и охраны учреждается Красная книга почв Российской Федерации…». Обнадеживает тот факт, что «застолбили» отношение к почвам. Они подлежат охране и учету. Но по букве статьи закона охране и учету, опять же, подлежат только редкие и исчезающие почвы.

Аналогично воспринимается задекларированное в пункте 2 этой статьи положение «об установлении режима использования земельных участков, почвы которых отнесены к редким, и находящимся под угрозой исчезновения».

В системе особо охраняемых природных территорий Волгоградской области не представлены такие ценные природные объекты как почвенные эталоны, что в значительной мере снижает эффективность природоохранной деятельности. В целом в Волгоградской области преобладают особо охраняемые объекты регионального значения. По видам биотопов большая часть приходится на лесные и степные комплексные объекты (Доклад…, 2004).

Общая площадь особо охраняемых лесных территорий составляет 18,7 тыс. га, или 2,7 % от всех земель лесного фонда (Доклад…, 2004). На землях лесного фонда расположено 19 особо охраняемых лесных территорий, из них выделено 14 особо ценных лесных массивов, 4 памятника природы и один водный объект.

Например, Волго-Ахтубинская пойма – последний практически единственный участок долины Волги, сохранивший свое естественное строение. Водно-болотные угодья междуречья – экотон, сформированный на стыке степной и полупустынной зон, что само по себе уникально. Почвенный покров представлен редкими, эндемичными для сухостепной зоны плодородными пойменными почвами (Околелова, 2004, 2015).

В последние годы на территории Волгоградской области началась активная работа по формированию сети Природных парков. Первый в Волгоградской области Природный парк «Волго-Ахтубинская пойма» площадью 142,34 га создан на основании Закона Волгоградской области «Об охране природы Волго-Ахтубинской поймы» (Закон Волгоградской области…, 1998).

В 2001 году начал функционировать Природный парк «Донской» Волгоградской области (площадь 61,92 га). В следующем году был принят Закон «Об охране озера Эльтон» и образован парк «Эльтонский», площадью 106,04 га. В марте 2003 года был создан природный парк «Нижнехоперский» – самый большой по площади в области. Он расположен на территории трех административных районов – Алексеевского, Кумылженского, Нехаевского.

3.5. Почвы, отчужденные для несельскохозяйственного использования

Для реализации экологически совместимых технологий необходимо выделять «краснокнижные» почвенные объекты антропогенных ландшафтов. Основными составляющими в этом разделе являются: процедура отвода земель; мониторинг их состояния; рекультивация нарушенных земель.

Процедура отвода земель для несельскохозяйственных нужд – актуальный вопрос сохранения почвенных ресурсов, решающий фактор обеспечения экологической сбалансированности территории. Согласно ст. 88, п. 1 Земельного Кодекса РФ (Земельный кодекс РФ, 2001) «участки для разработки полезных ископаемых предоставляются после оформления горного отвода, утверждения проекта рекультивации земель, восстановления ранее отработанных земель».

Считаем, что в первую очередь отводу должны подлежать земли, не подлежащие рекультивации, при их отсутствии – малопродуктивные почвы. Отвод земель сельскохозяйственного назначения необходимо проводить с учетом вида землепользования и продуктивности почв.

На фоне усиления процессов деградации почв ограничение площади отвода земель под различные технологии требует самого тщательного обоснования и ювелирной регламентации. Тем более важна качественная рекультивация нарушенных земель. Для решения этого вопроса предлагаем создать региональный Регламент рекультивации земель, учитывающий природно-климатические особенности региона, виды технологий, реализованных на территории области. На основе кадастра почв можно разработать методику ранжирования территорий для возможности отведения их под технологические объекты различного назначения.

Статья 79. Земельного Кодекса предусматривает возможность отвода «особо ценных продуктивных сельскохозяйственных угодий», но при этом оговаривается условие «после отработки других сельскохозяйственных угодий». Сложность состоит в том, что в Земельном Кодексе нет критериев и определений, какие земли считаются ценными.

Земельный Кодекс (Земельный кодекс РФ, 2001, ст. 79, п. 3) ограничивает изъятие земель сельскохозяйственных угодий в целях предоставления для несельскохозяйственного использования угодий, кадастровая стоимость которых превышает свой среднерайонный уровень.

В.В. Докучаев (Докучаев, 1994: 62) считал, что для России по сравнению с другими европейскими странами у почвы особая роль: «В Европе нет другой страны, для которой земля имела хотя бы половину того значения, какое имеет она для нашего отечества».

Необходимо ввести паспорта почвенных контуров, по аналогии с экологическими паспортами ценных почвенных объектов (ЦПО), предложенными ранее Г.В. Добровольским и Е.Д. Никитиным (Добровольский, Никитин, 2000). В отличие от паспортов объектов ЦПО, паспорта почвенных контуров должны включать данные обо всех видах их использовании, а также о наличие временного отвода земель, с подробной информацией об их эксплуатации за период отвода.

## 3. Заключение

Почва, независимо от того, обитают в ней редкие беспозвоночные или нет, произрастают ли ценные виды флоры, достойна бережного отношения и сохранения в том виде, в котором она веками существует.

Все три предложенных статуса выделения «краснокнижных» почв тесно связаны между собой. Ценные по продуктивности почвы сельскохозяйственных угодий не выбывают из оборота. Они же включены в Красную книгу почв.

Отчужденные из сельскохозяйственного оборота во временное пользование земли, «навсегда» в своей биографии оставят информацию о виде и сроках ее эксплуатации, изменении состояния «здоровья» и останутся в разделе земель, отведенных для несельскохозяйственного использования. Как правило, эти земли также возвращаются в разряд сельскохозяйственных угодий. Поэтому очевидна необходимость интеграции сведений о почвах каждого раздела. Изложенные принципы создания Красной книги почв приемлемы не только для почв Волгоградской области, но и для почв Вьетнама.

**Литература**

Апарин и др., 2007 – *Апарин Б.Ф., Касаткина Г.А., Матинян Н.Н., Сухачева Е.Ю.* (2007). Красная книга почв Ленинградской области. СПб. 320 с.

Безуглова, 2009 – *Безуглова О.С.* (2009). Классификация почв. Ростов-на-Дону: ЮФУ. 128 с.

Деградация и охрана почв, 2002 – Деградация и охрана почв. 2002 / *Под ред. Г.В. Добровольского*. М: МГУ. 654 с.

Дегтярева, Жулидова, 1970 – *Дегтярева Е.Т., Жулидова А.Н.* (1970). Почвы Волгоградской области. Волгоград: Нижне-Волжское книжное издательство. 320 с.

Добровольский, Куст, 2004 – *Добровольский Г.В., Куст Г.С.* (2004). Концепция почвенных ресурсов: современное состояние, предпосылки к переосмыслению и постановка задач. // Почвы – национальное достояние России: Материалы 4 съезда Докучаевского общества почвоведов России. Новосибирск, кн. 1. 106-108.

Добровольский, Никитин, 2000 – *Добровольский Г.В., Никитин Е.Д.* (2000). Сохранение почв как независимого компонента биосферы. М.: Наука, Маик "Наукаинтерпериодика". 188 с.

Добровольский и др., 2004 – *Добровольский Г.В., Прохоров А.Н., Яковлев А.С., Березин П.Н.* (2004). Об охране почв / Почвы – национальное достояние России: Материалы 4 съезда Докучаевского общества почвоведов России. Новосибирск: кн. 1. 105.

Доклад …, 2004 – Доклад о состоянии окружающей среды Волгоградской области за 2003 год. Волгоград. 2004. 154 с.

Докучаев, 1994 – *Докучаев В.В.* (1994). Дороже золота русский чернозем. / Сост. Г.В. Добровольский. М: МГУ. 544 с.

Закон Волгоградской области…, 1998 – Закон Волгоградской области «Об охране природной среды Волго-Ахтубинской поймы» от 20.02.1998.

Закон Московской области…, 1995 – Закон Московской области от 18.04.1995 № 6/49 «Об отнесении земель сельскохозяйственного назначения к особо ценным и ценным».

Закон Чувашской республики…, 1995 – Закон Чувашской республики «Об охране земель и повышении плодородия почв Чувашской республики» от 17.10. 1995 № 16 с изменениями от 23. 10. 2000.

Земельный кодекс РФ, 2001 – Земельный кодекс РФ. Российская газета, 30.10. 2001, № 211-212.

Земельные ресурсы…, 1997 – Земельные ресурсы Волгоградской области / Под ред. А.В. Воробьева. Волгоград: Станица – 2, 1997. 132 с.

Земельные ресурсы…, 2004 – Земельные ресурсы Волгоградской области на 01.01.2004 года / Под ред. А.В. Воробьева. Волгоград: ООО «Изд-во «Волгоград», 2004. 48 с.

Земельный фонд…, 2003 – Земельный фонд Волгоградской области / Под ред. А.В. Воробьева. Волгоград: Изд. «Волгоград», 2003. 48 с.

Казеев и др., 2010 – *Казеев К.Ш., Вальков В.Ф., Колесников С.И.* (2010). Атлас почв юга России. Ростов-на-Дону: Эверест. 128 с.

Карпачевский, 1971 – *Карпачевский Л.О.* (1971). Охрана почв необходима. Охрана природы. Вып. 3. М.: Просвещение. С. 17–27.

Карпачевский и др., 1995 – *Карпачевский Л.О., Мотузова Г.В., Строганова М.Н., Малинина М.С.* (1995). Теоретические и практические основы изучения почв в заповедниках / Почвенные исследования в заповедниках. М. С. 6–16.

Классификация почв России, 2000 – Классификация почв России / Сост. Шишов Л.Л., Тонконогов В.Д., Лебедева И. И. М: Почвенный ин-т им. В.В. Докучаева, 2000. 236 с.

Климентьев, 2000 – *Климентьев А.И.* (2000). Почвы степного Зауралья. Екатеринбург. 434 с.

Климентьев, Блохин, 1996 – *Климентьев А.И., Блохин Е.В.* (1996). Красная книга почв Оренбургской области. Почвенные эталоны Оренбургской области. Екатеринбург: УРО РАН. 90 с.

Климентьев, Чибилев, 1999 – *Климентьев А.И., Чибилев А.А.* (1999). О разработке Красной книги почв и формировании системы почвенных эталонов степи // *География и природные ресурсы,* 3: 29–30.

Климентьев и др., 2001 – *Климентьев А.И., Чибилев А.А., Блохин Е.В., Грошев И.В.* (2001). Красная книга почв Оренбургской области. Екатеринбург: УрО РАН. 294 с.

Ковда, 1981 – *Ковда В.А.* (1981). Почвенный покров, его улучшение, использование и охрана. М: Наука, 1981. 182 с.

Красная книга..., 2017 – Красная книга почв Волгоградской области (2017). Ред. Кулик К.Н., Кретинин В.М., Рулев А.С., Шишкунов В.М. Волгоград: Комитет природных ресурсов, лесного хозяйства и экологии Волгоградской области. 224 с.

Методика..., 2000 – Методика государственной кадастровой оценки сельскохозяйственных угодий на уровне субъектов Российской Федерации. М: 2000. 63 с.

Никитин, 1982 – *Никитин Е.Д.* (1982). Роль почв в жизни природы. М: Знание. 47 с.

Никитин и др., 1987 – *Никитин А.Т., Степанов С.А., Забродин Ю.М. и др.* (1987). Экология, охрана природы и экологическая безопасность. М: МНЭПУ. 744 с.

Околелова, 2004 – *Околелова А.А.* (2004). Экологические функции почв // *Научная мысль Кавказа*. Приложение 8: 116–118.

Околелова, 2015 – *Околелова А.А.* (2015). Организация Генофонда почв // *Вестник академии Знаний*, 13(2): 4–7.

Околелова, Егорова, 2004 – *Околелова А.А., Егорова Г.С.* (2004). Генофонд почв Волгоградской области. Волгоград: РПК «Политехник». 100 с.

Околелова, Егорова, 2008 – *Околелова А.А., Егорова Г.С.* (2008). Фонд почвенно-генетического разнообразия Волгоградской области. Волгоград: ИПК «Нива». 104 с.

Околелова и др., 2006 – *Околелова А.А., Безуглова О.С., Егорова Г.С.* (2006). Экологические принципы сохранения почвенного покрова. Волгоград: РПК «Политехник». 96 с.

Околелова и др., 2014 – *Околелова А.А. Нгуен В.Т., Авилов В.К.* (2014). Свойства основных типов почв Биосферного заповедника Донг Най (Южный Вьетнам) // *Научные ведомости Белгородского государственного университета. Сер. Естественные науки*, 10(181)(27): 138–144.

Организация кадастрового учета..., 2004 – Организация кадастрового учета в России. Справочное пособие. М: 300с.

Охраняемые природные территории..., 1999 – Охраняемые природные территории. Материалы к созданию концепции системы охраняемых природных территорий России. М: РПО ВВФ, 1999. 246 с.

Положение о порядке возмещения убытков..., 1999 – Положение о порядке возмещения убытков собственникам земли, землевладельцам, землепользователям, арендаторам и потерь сельскохозяйственного производства, утвержденного постановлением Правительства РФ оот28.01.1993. № 77. П. 35 с изменениями от 27.12.1994, 27.11.1995, 01.07.1996, 15.05.1999.

Почвенно-экологический мониторинг..., 1994 – Почвенно-экологический мониторинг и охрана почв / Под ред. Д.С. Орлова, В. Д. Василевской. М: МГУ, 1994. 272 с.

Почвы..., 2012 – Почвы в биосфере и жизни человека. / Под ред. В.В. Добровольского и др. М: МГУ. 2012. 584 с.

Почвы Волгоградской области..., 1982 – Почвы Волгоградской области. Отчет. / Сост. Е.Т. Дегтярева, А.Н. Жулидова. Волгоград: ЮжНИИгипрозем, 1982. 340 с.

Почвы совхоза Трехостровской..., 1976 – Почвы совхоза Трехостровской Иловлинского района Волгоградской области и рекомендации по их использованию. Отчет. Росземпроект. Волг. Филиал ЮжНИИгипрозема. Волгоград: 1976. 74 с.

Почвы совхоза «Хоперский»..., 1974 – Почвы совхоза «Хоперский» Новониколаевского района Волгоградской области и рекомендации по их использованию. Отчет. Волгоград: ЮжНИИгипрозем, 1974. 116 с.

Пояснительная записка..., 2000 – Пояснительная записка к расчетам показателей оценки земель и производственного потенциала хозяйств Волгоградской области. ВолгоградНИИгипрозем, 2000. 6 с. Рукопись.

Программа защиты..., 1993 – Программа защиты земель от деградации, консервация эродированных земель и их восстановление в Волгоградской области. Отчет ЮжНИИгипрозема. Волгоград: 1993. 120 с.

Список почвенных разновидностей..., 1988 – Список почвенных разновидностей сельскохозяйственных угодий Волгоградской области. Волгоград: ЮжНИИгипрозем. 1988. 310 с.

Стифеев, А.И., 2019 – *Стифеев, А.И., Бессонова Е.А., Никитина О.В.* Система рационального использования и охрана земель. Ростов-на-Дону: Лань. 168 с.

Схема землеустройства..., 2003 – Схема землеустройства ГУ «Природный парк «Волго-Ахтубинская пойма». Волгоград: Отчет ОАО ВолгоградНИИгипрозем, 2003. 160 с.

Субрегиональная национальная программа..., 1999 – Субрегиональная национальная программа действий по борьбе с опустыниванием для юго-востока Европейской части. / Под ред. Е.С. Павловского, К.Н. Кулика. Волгоград: ВНИАЛМИ, 1999. 313 с.

Ташнинова, 2000 – *Ташнинова Л.Н.* (2000). Красная книга почв и экосистем Калмыкии. Элиста. 212 с.

Ташнинова, 2003 – *Ташнинова Л.Н.* (2003). Охрана почв как условие их устойчивости к антропогенному воздействию // Охрана почв Калмыкии и прилегающих территорий: Сб. Научных трудов. Вып. 2. Элиста. С. 5-10.

Технический отчет..., 1986 – Технический отчет по почвенному обследованию землепользования свх. «Комсомолец». Волгоград: ЮжНИИгипрозем, 1986. 154 с.

Технический отчет..., 1987 – Технический отчет по почвенному обследованию свх. «Пойменный» Среднеахтубинского района. Волгоград: ЮжНИИГипрозем, 1987. 100 с.

Технический отчет по почвенному..., 1987 – Технический отчет по почвенному обследованию свх. «Каршевитский», Ленинского района Волгоградской области. Волгоград: ЮжНИИгипрозем, 1987. 132 с.

Федеральный закон..., 2004 – Федеральный закон об охране окружающей среды. 2004. № 16 (199).

Фридланд, 1972 – *Фридланд В.М.* (1972). Структура почвенного покрова. М: Мысль. 424 с.

Фридланд, Буяновский, 1977 – *Фридланд В.М., Буяновский Г.А.* (1977). Просто Земля. М: Просвещение.143 с.

Чернова, 2002 – *Чернова О.В.* (2002). О создании Красной книги почв черноземной зоны России // *Почвоведение*, 12: 1495–1500.

Чернова и др., 2003 – *Чернова О.В., Севостьянова О.В., Богатырев Л.Г.* (2003). Принципы выбора эталонных объектов при создании красной книги почв России / Роль почв в биосфере: Труды института почвоведения МГУ им. М. В. Ломоносова и Российской Академии наук. Москва-Тула Вып. 1. С. 97–105.

Чернова, 2018 – *Чернова О.В.* (2018). Информационная справочная система «Красная книга почв». // Современное состояние черноземов. Труды межд. Научн. Конференции. 24–28 сентября 2018 г. Ростов-на-Дону: Т. 2: 205–212.

Chang, Chang, (1998) – *Chang Kong Tai, Chang Kong Han* (1998). State of the environment and soils of Vietnam: study of heavy metals / / *Journal of soil science of Vietnam*, 10: 152–160.

Chan, Nguyen, 1978 – *Chan Hai, Nguyen VI.* (1978). Study of chemical properties of soils in the North of Vietnam. Hanoi: Agricultural publishing house. 134 p.

Chan, Le, 1999 – *Chan Hai, Le Thai Bat* (1999). The condition of the soil of Vietnam // *Journal of soil science of Vietnam*, 12: 111–124.

Do, 1997 – *Do D.S.* (1997). Forest slope soils of Vietnam and nutrient and water management issues // Collection of scientific conference "Management of nutrients and water in plants on the Northern slopes of the North of Vietnam". Hanoi. pp. 47–55.

Do, Nguyen, 2001 – *Do D.S., Nguyen N.B.* (2001). Assessment of productivity of forest land in Vietnam. Hanoi: Publishing house of statistics. 205 p.

Do et al., 2006 – *Do D.S., Ngo D.K., Nguyen T.S., Nguyen N.B.* (2006). Soils and soil nutrients. The Forests handbook. The Ministry of Agriculture and Rural development (Vietnam). Hanoi. 124 p.

Dung et al., 1993 – *Dung V.V., Mong G., Nguyen N.C., Do T.P.* (1193). *Arctander and I Mackinnon*. A new species of living bovid from Viet Nam // Nature, 363: 443–445.

Enviromental indicators..., 1999 – Enviromental indicators: Typology and overview. 1999 Report. № 25. EEA. Copenhagen. 19 p.

Enviromental signals, 2000 – Enviromental signals. 2000. Enviromental Assessment Report № 6. EEA. Copenhagen. 20 p.

Fang, 1992 – *Fang Lieu* (1992). Soils in East Nambo. Hanoi: Agricultural publishing house. 150 p.

FAO, 2010 – FAO. Global Forest Resources Assessment. Main report – Forestry Paper 163. Rome, Italy. 2010. [Electronic resource]. URL: www.fao.org/forestry/fra/fra2010/en/

Forest Inventory..., 1995 – Forest Inventory and Planning Institute (FIPI). Forest cover and its change in the period of 1991–1995. Hanoi, 1995. 78 p.

Groombridge, Jenkins, 2000 – *Groombridge B., Jenkins M.D.* (2000). Global Biodiversity: Earth's Living Resources in the 21st Century. Cambridge, World Conservation Press.

Hämäläinen, 2014 – *Hämäläinen M.* (2014). *Atrocalopteryx auco* spec. nov. from Vietnam, with taxonomic notes on its congeners (*Odonata: Calopterygidae*) // *Zootaxa,* 3793(5): 561–572.

Ho, Kazuhico, 2001 – *Ho Thi Lam Tra, Kazuhico Egashira* (2001). Status of Heavy metals in Agricultural Soils of Vietnam // *Soil Science and Plant Nutrition*, 47(2): 419–422.

IUSN, 2019 – *IUSN* (2019). International Union for Conservation of Nature (IUSN). Red list of Threatened Species. [Electronic resource]. URL: https://www.iucnredlist.org/ (date of access 2019-06-18)

Khao et al., 1979 – *Khao Liam, Chuong Kong Ting, Chang Wang Tian* (1979). Soils in East Nambo // *Soil Studies,* 2: 2–40.

Le, 1978 – *Le Duc An* (1978). The characters of the basal cover of South Vietnam // *Geological map*., 36: 44–54.

Le, 1981a – *Le Van Hoa* (1981a). Chemical features of ferality soils on shale under the tea plantation province Vinfo // *Scientific and technical agricultural magazine*, 6: 347-351.

Le, 1981b – *Le Van Hoa* (1981b). Gross and mobile forms of Mn, Cu, and Mo in soils of the province Phutho // *Scientific and technical agricultural magazine*, 9: 533-536.

Le, 1982 – *Le Van Hoa* (1982). The content and relationship between the forms of Mn in soils on different rocks // *Scientific and technical-agricultural journal,* 9: 396-400.

Le, 2009 – *Le Huy B.A.* (2009). Soil resources of Vietnam. Ho Chi Minh city: Publishing house of education. 1230 p.

Le et al., 2009 – *Le Quoc Hung, Dang Ngoc Quang, Bui Thi Luong* (2009). Analysis of the black Lingzhi newly-found from national park of Cat Tien, South Vietnam // *Journal of Biology. Hanoi,* 31(4): 55–64.

Long-Fei et al., 2014 – *Long-Fei Fu, Van Truong Do, Fang Wen, He Cheng-Xin.Fu, Van Truong Do, Fang Wen, He Cheng-Xin* (2014). *Elatostema arcuatobracteatum* (Urticaceae), a new species from Vietnam // *Phytotaxa*, 174 (2): 111–115.

May et al., (1995) – *May R.M., Lawton J.H., Stork N.E.* (1995). Assessing extinction rates. In J.H. Lawton and R.M. May (ed.), Extinction Rates. Oxford. Oxford University Press.

Ministry of forests…, 1992 – Ministry of forests of Vietnam. Technical and economic justification of the national Park Cat Tien. Hanoi. 70 p.

Ministry of agriculture…, 2013 – Ministry of agriculture and agricultural development of Vietnam. State of forests in Vietnam in 2012. Hanoi, 2013. 8 p.

Monitoring centre…, 2012 – Monitoring centre and technology of the environment the province of Dong Nai. Report on soil quality in 2012 in Dong Nai province. Dong Nai, 2012. 4 p.

Monitoring centre…, 2013 – Monitoring centre and technology of the environment the province of Dong Nai. Report on soil quality in 2013 of Dong Nai province. Dong Nai, 2013. 4 p.

Moorman, 1960 – *Moorman F.R.* (1960). The soil map of the South of Vietnam. Scale 1/1.000.000. Saigon.

Ngo, 1978 – *Ngo Van Phu* (1978). The effect of environmental factors on the properties of humus ferality soils on basalts province of Lam Dong // *Scientific and technical agricultural magazine*, 8: 574-577.

Ngo, 1979 – *Ngo Van Phu* (1979). Properties of organic matter in the main groups of soils in Vietnam // *Soil research. Hanoi,* 6. 62 p.

Ngo, 1988 – *Ngo Nhat Tien* (1988). Properties of mineral soil compounds of the province of Kangning. Thesis for the degree of candidate of agricultural Sciences. Hanoi: Institute of agriculture. 80 p.

Ngo et al., 1991 – *Ngo Nhat Tien, Do Dinh Sam, Hoang Xuan Ti* (1991). Forest soils-achievements in their research and operation // *Journal of soil science of Vietnam*, 3: 8-9.

Nguyen, 1996 – *Nguyen Ngoc Binh* (1996). Forest soils of Vietnam. Vietnam Institute of forest Sciences. Hanoi: Agricultural publishing house. 155 p.

Nguyen, 1988 – *Nguyen Quoc Thang* (1988). Preliminary list of reptiles and amphibians in Nam Cat Tien Forest Reserve // *Garrulax*, 5: 8-9.

Nguyen, 2010 – *Nguyen Van Toan* (2010). Soil resources of Vietnam // *Journal of soil science of Vietnam*, 33: 5-12.

Nguyen, Thai, 1999 – *Nguyen You Siem Reap, Thai Fien (1999)*. Mountain-hilly soils of Vietnam-degradation and restoration. Hanoi: Agricultural publishing house, 412 p.

Nguyen et al., 2009 – *Nguyen Huu Thanh. Pham The Anh, Nguyen Tien Si* (2009). A study of the state of humus ferrallitic soils on basalts under coffee plantation in the province of Daknong // *Journal of science and development. Hanoi agricultural University,* 7(4): 491-499.

Nguyen et al., 2013 – *Nguyen V.D., Lareshin V.G., Slobodyanuk K.V.* (2013). The humus state ferralitic soil ecosystems in the high land of Vietnam // *Bulletin of Peoples' Friendship University of Russia. Series Agronomy and Animal industries*, 1: 29–35.

Nguyen, Bui, 2018 – *Nguyen T.B.P., Bui M.H.* (2018). Variations of soil chemical properties at different horizons under natural forest canopy in Kon Ka Kinh National Park, Gia Lai // *Vietnam Journal of Forest Science*, 1: 83–92.

Nguyen et al., 2011 – *Nguyen Hoang Hao, Tran Van Mui, Nguyen Xuan Dang* (2011). Current population status of ungulates in Dong Nai culture-nature reserve, Dong Nai province / *Proceedings of the 4th National Scientific Conference on Ecology and Biological Resources. Hanoi,* 1655–1660.

Nguyen, Okolelova, 2014 – *Nguyen Van Thinh, Okolelova A.A.* (2014). Protected natural areas of South Vietnam –Dong Nai Biospyere Reserve // *Biogeosystem Technique,* 2: 191-200.

Nguyen et al., 2018 – *Nguyen Van Thinh., Okolelova A.A. et al.* (2018). Organic Carbon and Tonal Nitrogen in Soil of Kon Kf Kinh National Park // *Biogeosystem Technique,* 5(1): 141-146.

Park, 2004 – *Park Cat Tien* (2004). Message of the project for the conservation of the national Park Cat Tien. Dong Nai. 148 p.

Pham, 1994 – *Pham Kang Ha* (1994). Soils and systems of their use in agriculture of Eastern Nambo. Thesis for the degree of candidate of agricultural Sciences, Hanoi: Institute of scientific and technical agriculture of Vietnam. 164 p.

Pham, 1995 – *Pham Kang Ha* (1995). The resource soil in East Nam Bo – status and prospects. Hanoi: Agricultural publishing house. 145 p.

Pham, 2011 – *Pham Kang Ha* (2011). Heavy metals status in sediment at Can Gio mangrove Ho Chi Minh city, Vietnam // *Journal of Biology*, 33(3):81-86.

Pham et al., 2001a – *Pham Kang Ha, Tran Thi Tam, In Dinh Cang, Nguyen Thi Hien* (2001). Influence of pollution of soils of the suburban area due to the placement of industrial and urban waste // *Journal of agricultural and agricultural development*, 6: 363-364.

Pham et al., 2001b – *Pham Nhat, Nguyen Xuan Dang, Polet G.* (2001). Field guide to the key mammal species of Cat Tien National Park. Ho Chi Minh City: Ho Chi Minh City Publishing House. 146 p.

Proposal..., 2001 – Proposal for a European soil monitoring and assessment framework. 2001. Project manager Gentile A. R. EEA Copenhagen. 58 p.

Rajendra et al, 1997 – Rajendra P. et al. (1997). Soil fertility management for sustainable agriculture. CRC. pp. 2-57.

Sala et al., (2000) – *Sala O.E., Chapin F.S., Armesto J.J. et al.* (2000). Global biodiversity scenarios for the year 2000 // *Science*, 287: 1770-1774.

Soil map..., 1991 – Soil map of Dong Nai province. The scale of 1/200.000. Institute of agricultural planning and design. Dong Nai: 1991.

Society..., 2000 – Society of soil scientists of Vietnam. The Soil of Vietnam. Hanoi: Agricultural publishing house, 2000. 412 p.

Soil map..., 2003 – Soil map of Dong Nai province. The scale of 1/200.000. Institute of agricultural planning and design. Dong Nai: 2003.

Soil map..., 2004 – Soil map of Cat Tien national Park. Scale 1/50.000. Institute of forest inventory and planning Nambo. Ho Chi Minh city. 2004.

Stevenson, 1982 – *Stevenson F.J.* (1982). Humus chemistry genesis, composition, reactions // *Wiley interscience publication. John Wiley and Sons*: 18–126.

Tone, Le, 2000 – *Tone That Chieu, Le Thai Baht* (2000). Soil classification and soil map of Vietnam. Hanoi: Agricultural publishing house. 198 p.

Thai, 1964 – *Thai Cong Tung* (1964). Soil use in South Vietnam: state and prospects. Saigon: Publisher House Thien Lia. 34 p.

Thai, 1970 – *Thai Cong Tung* (1970). General soil science: the Nature and properties of soils. Saigon: Publisher House Thien Lia. 548 p.

Thai, 1972 – *Thai Cong Tung (1972).* Soil plateau and South-Eastern Vietnam. Saigon: Publishing House Thien Lia. 35 p.

To, Nguyen, 2001 – *To Dinh Sam, Nguyen Ngoc Binh* (2001). Assessment of potential of forest soils of Vietnam. Hanoi: Publishing House of Statistics. 205 p.

To et al., 2006 – *To Dinh Sam, Ngo Dinh Ke, Nguyen You Siem, Nguyen Ngoc Binh* (2006). Forest soils and their fertility. Ministry of agriculture and rural development. Hanoi. 124 p.

Vu et al., 1963 – *Vu Ngoc Tuyen, Tran Hai Pham, MS Tu* (1963). The main groups of soils in the North of Vietnam. Hanoi: Agricultural Publishing House. 298 p.

WWF, 2008 – World wide Fund for nature (WWF) (2008). Instrument for the identification of specially protected forests in Viet Nam. WWF-Vietnam program. Hanoi. 99 p.

**References**

Aparin et al., 2007 – *Aparin B.F., Kasatkina, A.G., Matinyan N.N., Sukhacheva E.Y.* (2007). Red book of soils of the Leningrad region. SPb. 320 p.

Bezuglova, 2009 – *Bezuglova O.S.* (2009). Classification of soils. Rostov-on-Don: SFU Publishing House. 128 p.

Degradation..., 2002 – Degradation and protection of soils. Ed. G.V. Dobrovolsky. M. MSU, 2002. 654 p.

Degtyareva, Gulidova, 1970 – *Degtyareva E.T., Gulidova A.N.* (1970). The soils of the Volgograd region. Volgograd: Nizhne-Volzhskoe book publishing house. 320 p.

Dobrovolsky, Kust, 2004 – *Dobrovolsky G.V., Kust G.S.* (2004). The Concept of soil resources: the current state, the prerequisites for rethinking and problem setting. Soil is national treasure of Russia: Materials 4 Congress Dokuchaev society of soil scientists of Russia. Novosibirsk T. 1. pp. 106–108.

Dobrovolsky, Nikitin, 2000 – *Dobrovolsky G.V., Nikitin E.D.* (2000). Preservation of soils as an independent component of the biosphere. Moscow: Science, MAIK "Naukainterperiodika". 188 p.

Dobrovolsky et al., 2004 – *Dobrovolsky, G.V., Prokhorov A.N., Yakovlev A.S., Berezin, P.N.* (2004). On soil protection. Soil – national treasure of Russia: proceedings of the 4 Congress of Dokuchaev society of soil scientists. Novosibirsk: T. 1. 105 p.

Report ..., 2004 – Report on the Environment State of the Volgograd Region for 2003. Volgograd. 154 p.

Dokuchaev, 1994 – *Dokuchaev V.V.* (1994). More than gold Russian chernozem. Comp. G. V. Dobrovolsky. M: Moscow state University publishing house. 544 p.

Law..., 1998 – The law of the Volgograd region "On environmental protection of the Volga-Akhtuba floodplain" of 20.02.1998.

Law of the Moscow Region ..., 1995 – Law of the Moscow Region of April 18, 1995 No. 6/49 “On Assigning Agricultural Lands as Especially Valuable”.

Law of the Chuvash Republic..., 1995 – Law of the Chuvash Republic "On protection of land and soil fertility of the Chuvash Republic" of 17.10. 1995. Number 16 as amended by 23. 10. 2000.

Land code..., 2001 – Land code of the Russian Federation Russian newspaper, 30.10. 2001, number 211-212.

Land resources..., 1997 – Land resources of the Volgograd region. Ed. A.V. Vorob'eva. Volgograd: Stanitsa – 2, 1997. 132 p.

Land resources..., 2004 – Land resources of Volgograd region on 01.01.2004 the year, ed. by A.V. Vorob'eva. Volgograd: OOO "Izd-vo Volgograd, 2004. 48 p.

Land Fund..., 2003 – The land Fund of the Volgograd region, ed. by A.V. Vorob'eva. Volgograd: Publishing House "Volgograd", 2003. 48 p.

Kazeev et al., 2010 – *Kazeev K.Sh., Valkov V.F., Kolesnikov S.I.* (2010). Atlas of soils of the South of Russia. Rostov-on-Don: Everest. 128 p.

Karpachevsky, 1971 – *Karpachevsky L.O.* (1971). Soil protection is necessary. Nature protection. Vol. 3. M: Education. pp. 17–27.

Karpachevsky et al., 1995 – *Karpachevsky L.O., Motuzova G.V., Stroganova M.N., Malinina M.S.*(1995). Theoretical and practical bases of soil study in nature reserves. Soil research in nature reserves. M. pp. 6–16.

Classification..., 2000 – Classification of soils in Russia. Comp. Shishov L.L., Tonkonogov V.D., Lebedeva I. I. M: Soil Inst. named after V.V. Dokuchaev, 2000. 236 p.

Klimentyev, 2000 – *Klimentyev A.I.* (2000). Soils of the steppe TRANS-Urals. Ekaterinburg. 434 p.

Klimentyev, Blokhin, 1996 – *Klimentyev A.I., Blokhin E.V.* (1996). The Red book of soils of Orenburg region. Soil standards of the Orenburg region. Ekaterinburg, Ural branch, Russian Academy of Sciences. 90 p.

Klimentyev, Chibilev, 1999 – *Klimentyev A.I., Chibilev A.A.* (1999). About development of the Red book of soils and formation of system of soil standards of the steppe. *Geography and natural resources,* 3: 29-30.

Klimentyev et al., 2001 – *Klimentyev A.I., Chibilyov A.A., Blokhin E.V., Groshev I.V.* (2001). The Red book of soils of Orenburg region. Ekaterinburg: UrO RAS. 294 p.

Kovda, 1981 – *Kovda V.A.* (1981). Soil cover, its improvement, use and protection. M. 182 p.

Red Book ..., 2017 – Red Book of Volgograd Oblast Soils (2017). Ed. Kulik K.N., Kretinin V.M., Rulev A.S., Shishkunov V.M. Volgograd: Committee of Natural Resources, Forestry and Ecology of the Volgograd Region. 224 p.

Methods.., 2000 – Methods of state cadastral evaluation of agricultural land at the level of the Russian Federation, 2000. M. 63 p.

Nikitin, 1982 – *Nikitin E.D.* (1982). The Role of soils in the life of nature. M: Knowledge. 47 p.

Nikitin et al., 1987 – *Nikitin E.D., Stepanov S.A., Zabrodin Yu.M. et al.* (1987). Ecology, environment protection and ecological safety. M: MNEPU. 744 p.

Okolelova, 2004 – *Okolelova A.A.* (2004). The Ecological function of soils. *Scientific thought of Caucasus*, 8: 116–118.

Okolelova, 2015 – *Okolelova A.A.* (2015). The Organization of the Gene pool of the soil. *Bulletin of the Academy of Knowledge*, 13(2): 4-7.

Okolelova, Egorova, 2004 – *Okolelova A.A., Egorova G.S.* (2004). Soil gene Pool of the Volgograd region. Volgograd: RPK "Polytechnic". 100 p.

Okolelova, Egorova, 2008 – *Okolelova A.A., Egorova G.S.* (2008). Fund of soil-genetic diversity of the Volgograd region. Volgograd: PKI "Field". 104 p.

Okolelova et al., 2006 – *Okolelova A.A., Bezuglova O.S., Egorova G.S.* (2006). Ecological principles of preservation of soil cover. Volgograd: RPK "Polytechnic". 96 p.

Okolelova et al., 2014 – *Okolelova A.A. et al.* (2014). Properties of basic types of soils in the Dong Nai Biosphere reserve (South Vietnam). *Belgorod State University Scientific Bulletin – Natural sciences*, 10(181-27): 138-144.

Protected..., 1999 – Protected natural area. Materials for the creation of the concept of the system of protected natural areas of Russia. M: RPO WWF, 1999. 246 p.

Organization of land cadastre..., 2004 – Organization of land cadastre in Russia. Reference book. M. 2004. 300 p.

Regulations on the procedure for compensation for damages ..., 1999 – Regulations on the procedure for compensation for losses to landowners, landowners, land users, tenants and losses of agricultural production, approved by a decree of the Government of the Russian Federation dated January 28, 1993. No. 77. P. 35 as amended on 12/27/1994, 11/27/1995, 07/01/1996, 15/05/1999.

Soil-ecological monitoring..., 1994 – Soil-ecological monitoring and soil protection. Ed D.S. Orlov, V.D. Vasilevskaya. M: Moscow State University Publishing House, 1994. 272 p.

Soil..., 2012 – Soil in the biosphere and human life. Ed. V.V. Dobrovolsky. et al. M.: MSU, 2012. 584 p.

Soils..., 1982 – The soils of the Volgograd region. Report. / Comp. E.T. Degtyarev, A.N. Gulidova. Volgograd: YUZHNIIGIPROGAZ, 1982. 340 p.

Soil..., 1976 – The soil of the farm Trehostrovsky Ilovlinskн district of the Volgograd region and recommendations for their use. Report. Rosenrot. River volga. Volgograd: Branch YUZHNIIGIPROGAZ, 1976. 74 p.

Soils ..., 1974 – Soils of the farm "Hopersky" of Novonikolaevsky district of Volgograd region and recommendations for their use. Report. Volgograd: YUZHNIIGIPROGAZ, 1974. 116 p.

Explanatory note ..., 2000 – Explanatory note to the calculations of indicators for assessing land and production potential of farms in the Volgograd region. Volgograd NII Hyprozem, 2000. 6 p. Manuscript.

Protection Program ..., 1993 – Program for the protection of lands from degradation, conservation of eroded lands and their restoration in the Volgograd region. Report YuzhNIIgiprozema. Volgograd: 1993. 120 p.

List of soil varieties ..., 1988 – List of soil varieties of agricultural land in the Volgograd region. Volgograd: YuzhNIIgiprozem. 1988. 310 p.

Scheme..., 2003 – Scheme of land management GU "Natural Park Volga-Akhtuba floodplain". OJSC Volgogradnipineft Report. Volgograd: 2003. 160 p.

Subregional..., 1999 – Subregional national program of action to combat desertification for the South-East of the European part. M., Ed. NIA-Priroda MPR. Eds E.S. Pavlovsky, K.N. Kulik. Volgograd: VENIALI, 1999. 313 p.

Tashninova, 2000 – *Tashninova L.N.* (2000). The red book of soils and ecosystems of Kalmykia. Elista. 212 p.

Tashninova, 2003 – *Tashninova L.N.* (2003). Protection of soils as a condition of their resistance to anthropogenic impact. Protection of soils of Kalmykia and adjacent territories: SB. Scientific papers. Elista, 2: 5-10.

Technical report..., 1986 – Technical report on soil survey of land use of TSW. «Komsomolets.» Volgograd: YUZHNIIGIPROGAZ, 1986. 154 p.

Technical report..., 1987 – Technical report on soil survey of BW. «Floodplain» Sredneahtubinskogo district. Volgograd: YUZHNIIGIPROGAZ, 1987. 100 p.

Technical report on soil survey..., 1987 – Technical report on soil survey of BW. "Korchevatsky", Leninsky district, Volgograd region. Volgograd: YUZHNIIGIPROGAZ, 1987. 132 p.

Federal law..., 2004 – Federal law on environmental protection No 16 (199). 2004.

Fridland, 1972 – *Fridland V.M.* (1972). Soil Cover Structure. M: Thought. 424 p.

Fridland, Buyanovskii, 1972 – *Fridland V.M., Buyanovskii G.A.* (1972). Just The Land. M.: Enlightenment. 143 p.

Tscekh, Hiltmeyer-Erhard, 2007 – *Tscekh V., Hiltmeyer-Erhard G.* (2007). Soil. World Atlas. M.: Academy, St. Petersburg State University. 120 p.

Chernova, 2002 – *Chernova O.V.* (2002). About creation of the red book of soils of the Chernozem zone of Russia. *Soil Science*, 12: 1495–1500.

Chernova et al., 2003 – *Chernova O.V., Sevostyanova O.V., Bogatyrev L.G.* (2003). Principles of selection of reference objects for creating the Red book of soils of Russia. *The role of soils in the biosphere: Proceedings of the Institute of soil science of Moscow state University. M.V. Lomonosov and the Russian Academy of Sciences*. Moscow – Tula, 1: 97-105.

Chernova, 2018 – *Chernova O.V.* (2018). Information reference system «Red book of soils» Curent state of chernozems. International scientific congruence 24-28 September 2018. Rostov-on-Don, 2: 205-212.

Chang, Chang, (1998) – *Chang Kong Tai, Chang Kong Han* (1998). State of the environment and soils of Vietnam: study of heavy metals. *Journal of soil science of Vietnam*, 10: 152-160.

Chan, Nguyen, 1978 – *Chan Hai, Nguyen VI.* (1978). Study of chemical properties of soils in the North of Vietnam. Hanoi: Agricultural publishing house. 134 p.

Chan, Le, 1999 – *Chan Hai, Le Thai Bat* (1999). The condition of the soil of Vietnam. *Journal of soil science of Vietnam*, 12: 111-124.

Do, 1997 – *Do D.S.* (1997). Forest slope soils of Vietnam and nutrient and water management issues // Collection of scientific conference "Management of nutrients and water in plants on the Northern slopes of the North of Vietnam". Hanoi. pp. 47-55.

Do, Nguyen, 2001 – *Do D.S., Nguyen N.B.* (2001). Assessment of productivity of forest land in Vietnam. Hanoi: Publishing house of statistics. 205 p.

Do et al., 2006 – *Do D.S., Ngo D.K., Nguyen T.S., Nguyen N.B.* (2006). Soils and soil nutrients. The Forests handbook. Ministry of Agriculture and Rural development (Vietnam). Hanoi. 124 p.

Dung et al., 1993 – *Dung V.V., Mong G., Nguyen N.C., Do T.P.* (1193). *Arctander and I Mackinnon*. A new species of living bovid from Viet Nam. *Nature*, 363: 443-445.

Enviromental indicators..., 1999 – Enviromental indicators: Typology and overview. 1999 Report. № 25. EEA. Copenhagen. 19 p.

Enviromental signals, 2000 – Enviromental signals. 2000. Enviromental Assessment Report № 6. EEA. Copenhagen. 20 p.

Fang, 1992 – *Fang Lieu* (1992). Soils in East Nambo. Hanoi: Agricultural publishing house. 150 p.

FAO, 2010 – FAO. Global Forest Resources Assessment. Main report – Forestry Paper 163. Rome, Italy. 2010. [Electronic resource]. URL: www.fao.org/forestry/fra/fra2010/en/

Forest Inventory..., 1995 – Forest Inventory and Planning Institute (FIPI). Forest cover and its change in the period of 1991–1995. Hanoi, 1995. 78 p.

Groombridge, Jenkins, 2000 – *Groombridge B., Jenkins M.D.* (2000). Global Biodiversity: Earth's Living Resources in the 21st Century. Cambridge, World Conservation Press.

Hämäläinen, 2014 – *Hämäläinen M.* (2014). *Atrocalopteryx auco* spec. nov. from Vietnam, with taxonomic notes on its congeners (*Odonata: Calopterygidae*). *Zootaxa,* 3793(5): 561–572.

Ho, Kazuhico, 2001 – *Ho Thi Lam Tra, Kazuhico Egashira* (2001). Status of Heavy metals in Agricultural Soils of Vietnam. *Soil Science and Plant Nutrition*, 47(2): 419–422.

IUSN, 2019 – *IUSN* (2019). International Union for Conservation of Nature (IUSN). Red list of Threatened Species. [Electronic resource]. URL: https://www.iucnredlist.org/ (date of access 2019-06-18).

Khao et al., 1979 – *Khao Liam, Chuong Kong Ting, Chang Wang Tian* (1979). Soils in East Nambo // *Soil Studies,* 2: 2-40.

Le, 1978 – *Le Duc An* (1978). The characters of the basal cover of South Vietnam. *Geological map*., 36: 44-54.

Le, 1981a – *Le Van Hoa* (1981a). Chemical features of ferality soils on shale under the tea plantation province Vinfo. *Scientific and technical agricultural magazine*, 6: 347-351.

Le, 1981b – *Le Van Hoa* (1981b). Gross and mobile forms of Mn, Cu, and Mo in soils of the province Phutho. *Scientific and technical agricultural magazine*, 9: 533-536.

Le, 1982 – *Le Van Hoa* (1982). The content and relationship between the forms of Mn in soils on different rocks. *Scientific and technical-agricultural journal,* 9: 396-400.

Le, 2009 – *Le Huy B.A.* (2009). Soil resources of Vietnam. Ho Chi Minh city: Publishing house of education. 1230 p.

Le et al., 2009 – *Le Quoc Hung, Dang Ngoc Quang, Bui Thi Luong* (2009). Analysis of the black Lingzhi newly-found from national park of Cat Tien, South Vietnam. *Journal of Biology. Hanoi,* 31(4): 55-64.

Long-Fei et al., 2014 – *Long-Fei Fu, Van Truong Do, Fang Wen, He Cheng-Xin.Fu, Van Truong Do, Fang Wen, He Cheng-Xin* (2014). *Elatostema arcuatobracteatum* (Urticaceae), a new species from Vietnam. *Phytotaxa*, 174 (2): 111-115.

May et al., (1995) – *May R.M., Lawton J.H., Stork N.E.* (1995). Assessing extinction rates. In J.H. Lawton and R.M. May (ed.), Extinction Rates. Oxford. Oxford University Press.

Ministry of forests..., 1992 – Ministry of forests of Vietnam. Technical and economic justification of the national Park Cat Tien. Hanoi. 70 p.

Ministry of agriculture..., 2013 – Ministry of agriculture and agricultural development of Vietnam. State of forests in Vietnam in 2012. Hanoi, 2013. 8 p.

Monitoring centre..., 2012 – Monitoring centre and technology of the environment the province of Dong Nai. Report on soil quality in 2012 in Dong Nai province. Dong Nai, 2012. 4 p.

Monitoring centre..., 2013 – Monitoring centre and technology of the environment the province of Dong Nai. Report on soil quality in 2013 of Dong Nai province. Dong Nai, 2013. 4 p.

Moorman, 1960 – *Moorman F.R.* (1960). The soil map of the South of Vietnam. Scale 1/1.000.000. Saigon.

Ngo, 1978 – *Ngo Van Phu* (1978). The effect of environmental factors on the properties of humus ferality soils on basalts province of Lam Dong. *Scientific and technical agricultural magazine*, 8: 574–577.

Ngo, 1979 – *Ngo Van Phu* (1979). Properties of organic matter in the main groups of soils in Vietnam. *Soil research. Hanoi,* 6. 62 p.

Ngo, 1988 – *Ngo Nhat Tien* (1988). Properties of mineral soil compounds of the province of Kangning. Thesis for the degree of candidate of agricultural Sciences. Hanoi: Institute of agriculture. 80 p.

Ngo et al., 1991 – *Ngo Nhat Tien, Do Dinh Sam, Hoang Xuan Ti* (1991). Forest soils-achievements in their research and operation. *Journal of soil science of Vietnam*, 3: 8-9.

Nguyen, 1996 – *Nguyen Ngoc Binh* (1996). Forest soils of Vietnam. Vietnam Institute of forest Sciences. Hanoi: Agricultural publishing house. 155 p.

Nguyen, 1988 – *Nguyen Quoc Thang* (1988). Preliminary list of reptiles and amphibians in Nam Cat Tien Forest Reserve. *Garrulax*, 5: 8-9.

Nguyen, 2010 – *Nguyen Van Toan* (2010). Soil resources of Vietnam. *Journal of soil science of Vietnam*, 33: 5-12.

Nguyen, Thai, 1999 – *Nguyen You Siem Reap, Thai Fien (1999).* Mountain-hilly soils of Vietnam-degradation and restoration. Hanoi: Agricultural publishing house, 412 p.

Nguyen et al., 2009 – *Nguyen Huu Thanh. Pham The Anh, Nguyen Tien Si* (2009). A study of the state of humus ferrallitic soils on basalts under coffee plantation in the province of Daknong. *Journal of science and development. Hanoi agricultural University,* 7(4): 491-499.

Nguyen et al., 2013 – *Nguyen V.D., Lareshin V.G., Slobodyanuk K.V.* (2013). The humus state ferralitic soil ecosystems in the high land of Vietnam. *Bulletin of Peoples' Friendship University of Russia. Series Agronomy and Animal industries*, 1: 29-35.

Nguyen, Bui, 2018 – *Nguyen T.B.P., Bui M.H.* (2018). Variations of soil chemical properties at different horizons under natural forest canopy in Kon Ka Kinh National Park, Gia Lai. *Vietnam Journal of Forest Science*, 1: 83-92.

Nguyen et al., 2011 – *Nguyen Hoang Hao, Tran Van Mui, Nguyen Xuan Dang* (2011). Current population status of ungulates in Dong Nai culture-nature reserve, Dong Nai province. *Proceedings of the 4th National Scientific Conference on Ecology and Biological Resources. Hanoi,* 1655-1660.

Nguyen, Okolelova, 2014 – *Nguyen Van Thinh, Okolelova A.A.* (2014). Protected natural areas of South Vietnam –Dong Nai Biospyere Reserve. *Biogeosystem Technique,* 2: 191-200.

Nguyen et al., 2018 – *Nguyen Van Thinh., Okolelova A.A. et al.* (2018). Organic Carbon and Tonal Nitrogen in Soil of Kon Kf Kinh National Park. *Biogeosystem Technique,* 5(1): 141-146.

Park, 2004 – *Park Cat Tien* (2004). Message of the project for the conservation of the national Park Cat Tien. Dong Nai. 148 p.

Pham, 1994 – *Pham Kang Ha* (1994). Soils and systems of their use in agriculture of Eastern Nambo. Thesis for the degree of candidate of agricultural Sciences, Hanoi: Institute of scientific and technical agriculture of Vietnam. 164 p.

Pham, 1995 – *Pham Kang Ha* (1995). The resource soil in East Nam Bo – status and prospects. Hanoi: Agricultural publishing house. 145 p.

Pham, 2011 – *Pham Kang Ha* (2011). Heavy metals status in sediment at Can Gio mangrove Ho Chi Minh city, Vietnam. *Journal of Biology*, 33(3):81–86.

Pham et al., 2001a – *Pham Kang Ha, Tran Thi Tam, In Dinh Cang, Nguyen Thi Hien* (2001). Influence of pollution of soils of the suburban area due to the placement of industrial and urban waste. *Journal of agricultural and agricultural development*, 6: 363-364.

Pham et al., 2001b – *Pham Nhat, Nguyen Xuan Dang, Polet G.* (2001). Field guide to the key mammal species of Cat Tien National Park. Ho Chi Minh City: Ho Chi Minh City Publishing House. 146 p.

Proposal..., 2001 – Proposal for a European soil monitoring and assessment framework. 2001. Project manager Gentile A. R. EEA Copenhagen. 58 p.

Rajendra et al, 1997 – Rajendra P. et al. (1997). Soil fertility management for sustainable agriculture. CRC. pp. 2-57.

Sala et al., (2000) – *Sala O.E., Chapin F.S., Armesto J.J. et al.* (2000). Global biodiversity scenarios for the year 2000. *Science*, 287: 1770-1774.

Soil map..., 1991 – Soil map of Dong Nai province. The scale of 1/200.000. Institute of agricultural planning and design. Dong Nai: 1991.

Society..., 2000 – Society of soil scientists of Vietnam. The Soil of Vietnam. Hanoi: Agricultural publishing house, 2000. 412 p.

Soil map..., 2003 – Soil map of Dong Nai province. The scale of 1/200.000. Institute of agricultural planning and design. Dong Nai: 2003.

Soil map..., 2004 – Soil map of Cat Tien national Park. Scale 1/50.000. Institute of forest inventory and planning Nambo. Ho Chi Minh city. 2004.

Stevenson, 1982 – *Stevenson F.J.* (1982). Humus chemistry genesis, composition, reactions. *Wiley interscience publication. John Wiley and Sons*: 18-126.

Tone, Le, 2000 – *Tone That Chieu, Le Thai Baht* (2000). Soil classification and soil map of Vietnam. Hanoi: Agricultural publishing house. 198 p.

Thai, 1964 – *Thai Cong Tung* (1964). Soil use in South Vietnam: state and prospects. Saigon: Publisher House Thien Lia. 34 p.

Thai, 1970 – *Thai Cong Tung* (1970). General soil science: the Nature and properties of soils. Saigon: Publisher House Thien Lia. 548 p.

Thai, 1972 – *Thai Cong Tung* (1972). Soil plateau and South-Eastern Vietnam. Saigon: Publishing House Thien Lia. 35 p.

To, Nguyen, 2001 – *To Dinh Sam, Nguyen Ngoc Binh* (2001). Assessment of potential of forest soils of Vietnam. Hanoi: Publishing House of Statistics. 205 p.

To et al., 2006 – *To Dinh Sam, Ngo Dinh Ke, Nguyen You Siem, Nguyen Ngoc Binh* (2006). Forest soils and their fertility. Ministry of agriculture and rural development. Hanoi. 124 p.

Vu et al., 1963 – *Vu Ngoc Tuyen, Tran Hai Pham, MS Tu* (1963). The main groups of soils in the North of Vietnam. Hanoi: Agricultural Publishing House. 298 p.

WWF, 2008 – World wide Fund for nature (WWF) (2008). Instrument for the identification of specially protected forests in Viet Nam. WWF-Vietnam program. Hanoi. 99 p.

## Принципы составления Красной книги почв во Вьетнаме и России

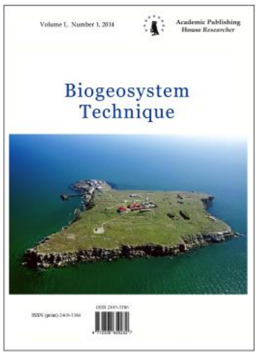
Алла Ароновна Околелова [a, *], Тхинь Ван Нгуен [b]

[a] Волгоградский государственный технический университет, Российская Федерация
[b] Южное отделение Российско-Вьетнамского тропического центра, Хошимин, Вьетнам

**Аннотация**. В настоящее время не существует надежных механизмов сохранения разнообразия почвенного покрова в целом, так как сведения о почвах рассредоточены по разным ведомствам, каждое из которых имеет свое представление о ценности почвенных объектов и способах его сохранения. В «краснокнижные» почвенные объекты внесены следующие взаимосвязанные элементы: 1) почвы сельскохозяйственных угодий; 2) почвы системы особо охраняемых природных территорий (СООПТ), включая почвы, занесенные в Красную книгу; 3) почвы, отчужденные для несельскохозяйственного использования. В качестве инструментов оценки продуктивности почв предложены следующие категории: оптимум или область благополучия, область нормального состояния, диапазон толерантности, экстремум. В основе разделения – балл бонитета. Предложено выделять ценные по продуктивности почвы сельскохозяйственных угодий, балл бонитета которых выше среднего в своем административном и земельно-оценочном районах, что послужит основой для организации щадящего режима их эксплуатации. Инициатива создания Красной книги почв, введения статуса «почвенный памятник природы» принадлежит российским ученым. Но уже и во Вьетнаме, на основе имеющихся заповедных территорий для сохранения биоразнообразия, работают над выявлением зональных типов почв и назначения им статуса, позволяющего вести мониторинг экосистем и обеспечивающего охрану почв. Юго-Восточная Азия – регион с очень высоким разнообразием флоры и фауны. Во Вьетнаме с возникновением национального парка Кук Фыонг в 1962 г. на севере страны, создается сеть природоохранных территорий. В настоящее время в стране существует 30 национальных парков, 58 заповедников и 46 охраняемых природных зон. В сети охраняемых природных территорий (International Union for Conservation of Nature network, IUCN) в Индокитае и Малайзии, именно Вьетнам характеризуется наиболее высоким уровнем эндемизма (WWW, 2008 FAO, 2010).

**Ключевые слова:** Красная книга почв, почвы сельскохозяйственных угодий России (Волгоградская область) и Вьетнама, почвы особо охраняемых природных территорий, почвы изъятые из сельскохозяйственного использования.

[*] Корреспондирующий автор
Адреса электронной почты: allaokol@mail.ru (A.A. Okolelova)

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**Biogeochemical Characteristics of Soils in the Dzunbayan Oil-Producing Area (Eastern Mongolia)**

Gantumur Sambuu [a], Lyudmila A. Garetova [b], Elena L. Imranova [b], Olga A. Kirienko [b], Natalia K. Fischer [b], Khaliun Gantumur [a, c], Galina V. Kharitonova [b, *]

[a] Mongolian State University of Science and Technology, Ulaanbaatar, Mongolia
[b] Institute of Water and Ecological Problems, Far East Branch of the Russian Academy of Sciences, Khabarovsk, Russian Federation
[c] China University of Petroleum, People's Republic of China

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**Abstract**

For balances approach to Sustainable Development Goals, the physical and chemical degradation of soils, biological degradation of soil organic matter in result of oil pollution were studied. The data on the particle-size distribution, the content of chemical components and the number of microorganisms in the soils of the Dzunbayan (East Gobi) oil-producing area are presented. The studied soils are characterized by a bimodal distribution of particles: the main fraction is coarse sand (200–2000 μm), it ranges from 40 to 60 %. It is accompanied by fine silt (2–20 μm), its content reaches 17 %. A high content of chromium, copper, strontium, rubidium, cesium and arsenic was identified in soils, which reflect the geochemical specificity of the geological province. Due to arid climate of the study area soils are characterized by an alkaline reaction pH 8.2–8.7. Soils initially non-saline near the well are highly saline (salinity up to 0.7–1.2 %), due to the mining technologies used. The content of petroleum hydrocarbons (HC) in the soils of the study area varies from 9 to 60 mg/kg with a maximum in the vicinity of the operating well. The microbial community of soils is characterized by a high degree of adaptation to the conditions of the arid zone, salinity, high pH values, at the same time these conditions limit the development of typical representatives of soil microbiocenoses – actinomycetes and, to a greater extent, microscopic fungi. The total number of heterotrophic bacteria (TNH) in the studied soil samples varied within 1.22–3.49 $10^6$ CFU/g of dry soil, the share of hydrocarbon oxidizing bacteria (HOB) was 12.6–18.9 % of TNH. The content of hydrocarbon oxidizing bacteria (HOB) in the microbial community of soil (within 20 %) corresponds to the concentration boundary of pollution by hydrocarbons for the studied soils (up to 60 mg/kg), which indicates that the microbial community is on the verge of fulfilling the ability to self-purification of the soil. The identified physico-chemical characteristics of the studied soils of the desert zone (dominance of sand fractions, high pH values, salinity) in combination with specific climatic conditions and features of

* Corresponding author
E-mail addresses: gkharitonova@mail.ru (G. Kharitonova)

the oil composition of the Dzunbayan deposit (prevalence of heavy paraffin fractions) characterize their low potential for self-purification from pollution by hydrocarbons. For sustainable solutions planning of the oil production, transportation, and pollution prevention the transcendental Biogeosystem Technique methodology will be helpful for Land Degradation Neutrality implementation.

**Keywords:** oil production, soil, salinity, pollution, hydrocarbons, bacteria, Mongolia.

## 1. Introduction

Aspiration to achieve the Sustainable Development Goals (SDGs) in 2015 adopted by the United Nations (UN) is of high importance to avoid further land degradation and to achieve the lofty goals of Land Degradation Neutrality (LDN) by 2030 is a base of the current and strategic world development framework agendas (Keesstra et al., 2018). Physical and chemical degradation of soils, biological degradation of soil organic matter in result of oil pollution are the worldwide environment and high cost problems (Villacís et al., 2016). The Dzunbayan oil deposit is located in the southeastern part of Mongolia in the province of Eastern Gobi, 440 km east of Ulaanbaatar. It belongs to the central part of the Dzunbayan depression and is located at an altitude of 760 m above sea level. The first geological studies of the Mongolia territory aimed at the exploration and assessment of oil reserves were carried out in the 1920s by American specialists N. Berkeley and S. Morris in the Gobi Desert. On the basis of these and other materials, in 1931, the American geologist D. Tenner predicted the existence of oil deposits in the country (Serebriakov, Kondratiev, 2012). Planned geological exploration at oil deposits in Mongolia began in 1934, with the help and participation of USSR specialists. Two oil deposits were discovered in the south and in the south-east of the country with estimated reserves of 45 million barrels.

By 1941, a geological survey was carried out in south-eastern Mongolia with the participation of the Mongolian geologist J. Dugersuren and the Soviet geologist Yu. Zhelubovsky. Signs of oil-bearing were identified in the Eastern Gobi in the Dzunbayan area, which subsequently led to the discovery of the Dzunbayan oil deposit, which was commissioned in 1948. In terms of their physicochemical properties, Dzunbayan oil is very viscous, heavy, with a high content of resinous components and paraffins, the yield of light fractions is only 5–6 %.

During the operation, more than 260 wells were drilled to a depth of 3 km. New structures favorable for oil and gas accumulations were established. The operation of wells is carried out by subsurface oil pumps. Currently, oil is produced by 168 wells with a flow rate of 30–100 barrels per day. The reserves of the Dunbayan deposit are estimated at 160 million barrels. The extracted oil (550 thousand barrels per month) is transported by tank wagons for processing to China.

Today in Mongolia there is a tendency to worsening conditions for the development of oil deposits associated with the formation depletion with easily recoverable oil reserves. In this regard, there is an increasing interest in technologies that increase the efficiency of deposit development. To increase oil recovery at the Dzunbayan field, it is planned to use the method of water-gas impact.

The aim of this work is to assess the state of the soil in the area of the Dzunbayan deposit, their lithological and mineral composition, as well as the state of the soil microbial complexes involved in the processes of soil self-purification from pollutants. In this paper, we focus on the SDG, and land restoration (Keesstra et al., 2016, 2018).

## 2. Objects and methods

The study area is located 45 km south of Sainshanda, East Gobi aimak. The exploration area of the Dzunbayan deposit is 5321 km², the operational area is 239.5 m². Soil samples were taken in December 2018 near one (44°27'07" N and 110°05'17" E) of the 168 wells along the perimeter at a distance of 2 m (polluted sample sites M1–M3), as control we used "unpolluted" sample sites M4 and M5 5 and 30 m from the well, because the main soil contamination occurs when oil is taken. Soil sampling and chemical analysis was carried out in accordance with IS 17.4.3.01-83.

For chemical and microbiological analyzes, soil samples (0.5 kg), from a depth of 0–20 cm, were selected by the envelope method. For particle size analysis, soil samples, dried to the air-dry state, were ground in a porcelain mortar with a pestle with a rubber tip and passed through a 2 mm mesh sieve. The granulometric composition of the samples as a whole was determined by the sieve method (fine earth fraction <2 mm) by laser diffraction (particle size distribution from 0.01 to

2000 μm) on a size analyzer particles (SALD-2300, SHIMADZU, Japan) (Fraunhofer, 1817; Vadjunina, Korchagina, 1973; Shein et al., 2017; Wolform, 2011). The total composition was determined by the X-ray fluorescence method (Pioneer S4, Bruker AXS, Germany) using the silicate analysis technique. The XRF analysis was carried out in the Analytical Centre at the Institute for Tectonics and Geophysics, Khabarovsk, Far East Branch of the Russian Academy of Sciences. Hydrogen test, determination of electrical conductivity (EC) and salinity (S) of soil water extract (1:5) was carried out using a combined meter (Seven Multi S-47k, Mettler-Toledo, Switzerland).

Determination of the mass fraction of hydrocarbons (HC) in the soils was performed according to the method (END F 16.1:2.2.22–98). The hydrocarbon fraction was isolated by extraction with carbon tetrachloride, purified from accompanying polar compounds on a column with aluminum oxide of the 2nd degree of Brockman activity. The measurements were carried out on the concentration meter (KN-2M, Sibekopribor, Russia).

The number of ecological-trophic groups of microorganisms in the soil was determined by methods generally accepted in soil microbiology (Netrusov et al., 2005).

## 3. Results and discussion

Particle size analysis

The studied soils are friable sandy formations of yellow-orange color. For the particle size distribution significant differences between the samples was not identified. The degree of granulometric differentiation associated with the morphostructural features of the area can be judged from the distribution of particles by volume and the number of particles of a certain size. Figure 1 shows typical particle distribution curves. Evaluation of the particle size distribution in soil by volume criterion showed that the studied soils are characterized by a bimodal particle distribution (Figure 1a). The main fraction is coarse sand (particles with a diameter of 200–2000 μm), it makes up from 40 to 60 % of the volume of particles. It is accompanied by a fine silt (particles with a diameter of 2–20 μm), the content of which reaches 17 %. Its content suggests a rather high ability of soils to adsorb hydrocarbons.

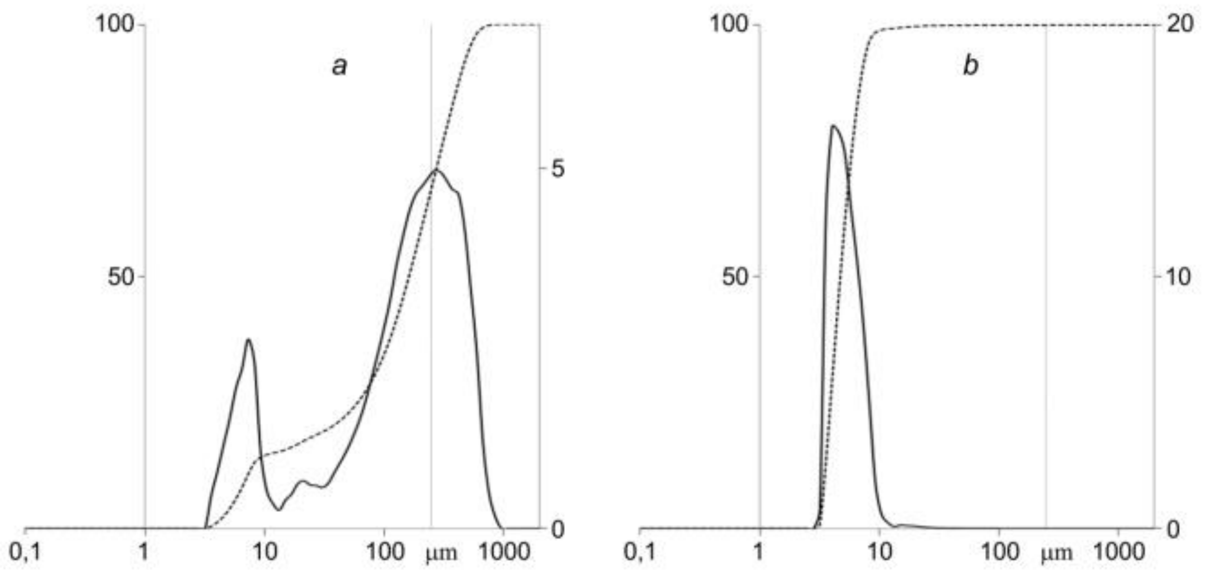


**Fig. 1**. Particle size distribution in the soils of the Dzunbayan deposit: *a* – by volume of particles; *b* – by the number of particles of a certain size. The solid line is the differential curves (auxiliary axis of ordinates), the dotted line is the integral curves (the main axis of ordinates)

Chemical content of soil

The study of the gross chemical composition of the soil showed the relative uniformity of distribution of the studied chemical components in them. Only in the M2 sampleincreased calcium content in comparison with other samples was revealed (Table 1). The content of iron oxide, which gives the soil an orange color, varied slightly – from 1.8 to 2.4 %, the content of aluminum oxide varied from 11.5 to 11.9 %. All samples revealed an elevated content of sodium oxides (3.6–4.3 %) and potassium (3.6–4.1 %), which is typical of sandy soils in this region (Liu et al., 2016).

The increased sodium content is reflected in the pH of the soil water extract, which is characterized by an alkaline condition and varies from 8.15 to 8.67 (Table 2) as in arid soils and in soils having a marine genesis (He et al., 2014). The alkaline reaction of the soil extract may also be due to the salinity of the soil. The salinity of the soil extract of the studied soil samples ranged from 0.13 to 2.37 ‰ and from 0.07 to 1.19% in soils correspondingly. The maximum salt content 0.7–1.2% is noted near the well (sample sites M1–M3). Such high salinity indicates soils as highly saline ones. With distance from the well salinity drops sharply and at a distance of 30 m is 0.07 % (M5), which corresponds to non-saline soils. Last with a high degree of confidence allows to assert that salinization is associated with mining technologies used.

**Table 1.** Gross chemical composition of soils in the Dzunbayan deposit (%)

| $M_xO_y$ | Sample | | | | |
|---|---|---|---|---|---|
| | M1 | M2 | M3 | M4 | M5 |
| $SiO_2$ | 81.74 | 75.93 | 80.16 | 79.61 | 82.17 |
| $TiO_2$ | 0.37 | 0.40 | 0.36 | 0.32 | 0.39 |
| $Al_2O_3$ | 11.83 | 11.59 | 11.70 | 10.90 | 11.90 |
| $Fe_2O3$ | 2.03 | 2.43 | 2.09 | 1.87 | 1.83 |
| MnO | 0.08 | 0.08 | 0.07 | 0.07 | 0.06 |
| CaO | 0.72 | 1.75 | 0.88 | 0.86 | 0.89 |
| MgO | 0.60 | 0.84 | 0.65 | 0.55 | 0.60 |
| $Na_2O$ | 4.09 | 4.27 | 4.01 | 3.64 | 3.82 |
| $K_2O$ | 3.91 | 3.60 | 3.82 | 3.76 | 3.93 |
| $P_2O_5$ | 0.05 | 0.06 | 0.06 | 0.05 | 0.06 |

It is known that electrical conductivity (EC) correlates with such soil properties as the cation exchange capacity of the soil, the content of organic matter and salinity (Li et al., 2011; He et al., 2014). In the studied samples, the EC of the water extract varied more significantly than the pH. Its maximum values were found in sample M2, where the EC was 4.5 mS/cm, as the EC removed from the well, the EC value decreased and at a distance of 30 m it was 0.3 mS/cm. Apparently, such a decrease in the EC value demonstrates a decrease in the HC content in the soil and its salinity.

The content of HC in soils varied from 9 to 60 mg/kg with the maximum content in samples taken at a distance of 2 m from the well (53–60 mg/kg, sampling site M1–M3). It should be noted that the problem of the maximum allowable concentration (MAC) on the content of hydrocarbons for the soil is practically not solved. Therefore, in the work of E.A. Rogozina (2006) it's proposed to assess the degree of pollution of soils by hydrocarbons by the excess of the content of HC over the background value in a specific area and in a specific territory. At the same time, in particular, it is indicated that for areas that do not produce oil, the background content of HC in the soil is 40 mg/kg, and for oil-producing areas – 100 mg/kg.

Under the classification of V.I. Uvarova (1989) according to the content of petroleum hydrocarbons (mg/kg of dry soil) soils can be divided into: clean – 0–5.5, slightly polluted – 5.5–25.5, moderately polluted – 25.6–55.5, polluted – 55.6–205.5, dirty – 205.6–500, very dirty > 500. If to adhere to this classification, then among the samples of the studied soils there are the following: clean – 0; slightly polluted – 2 samples (M4 and M5); moderately polluted – 1 sample (M3); polluted – 2 samples (M1 and M2). As in the case of soil salinization with distance from the well soil pollution by oil drops sharply and at a distance of 5 and 30 m are 15 and 9 mg/kg (M4 and M5), which corresponds to slightly polluted soils. The differences in the content of oil products at sampling sites M1 – M3 are statistically insignificant, which is due to the *a priori* conventionality of the classification boundaries.

**Table 2.** Physicochemical properties of soils in the Dzunbayan deposit

| Sample | Description of soil sample | HC*, mg/kg | Water extract | | |
|---|---|---|---|---|---|
| | | | EC, mS/cm | pH | S**, ‰ |
| M1 | Clay-sandy, yellow | 60 | 3.09 | 8.15 | 1.63 |
| M2 | Clay-sandy, bright yellow | 58 | 4.50 | 8.15 | 2.37 |
| M3 | Clay-sandy, yellow | 53 | 2.68 | 8.16 | 1.41 |
| M4 | Sandy-clay, light yellow | 15 | 0.74 | 8.67 | 0.30 |
| M5 | Sandy, light yellow | 9 | 0.32 | 8.16 | 0.13 |

*– electrical conductivity, ** – salinity (salt content)

The content of heavy metals in the studied soil samples is presented in Table 3. According to the standards established for sandy and loamy soils (HS 2.1.7.20.41-06), the excess of chromium at average was 4.2 and arsenic – 9.5 MAC. It should be noted that data on As require clarification: RFA analysis does not give a strictly quantitative assessment of its content in soils. However, the tendency of its accumulation in the soils of Mongolia is noted by many authors. The content of other rated metals did not exceed the MAC limits. The content of strontium, rubidium and cesium, which are in large quantities in the studied soil samples, is not subject to rationing and reflects the characteristics of the mineral composition of the soils of the studied geological province.

**Table 3.** The content of heavy metals in the soils of the Dzunbayan deposit, mg/kg

| Element | M1 | M2 | M3 | M4 | M5 | MAC |
|---|---|---|---|---|---|---|
| Cr | 26 | 27 | 27 | 24 | 24 | 6.0 |
| Cu | 1 | 5 | 4 | 3 | 0 | 3.0 |
| Zn | 32 | 34 | 32 | 30 | 31 | 23.0 |
| Pb | 36 | 34 | 35 | 35 | 34 | 32.0 |
| Co | 0 | 2 | 0 | 0 | 0 | 5.0 |
| Ni | 8 | 9 | 9 | 7 | 7 | 4.0 |
| Sr | 146 | 186 | 159 | 148 | 155 | – |
| V | 21 | 28 | 21 | 16 | 18 | 150.0 |
| Rb | 159 | 146 | 155 | 157 | 155 | – |
| Sn | 3 | 3 | 3 | 3 | 3 | – |
| Zr | 715 | 834 | 837 | 747 | 423 | – |
| As | 19 | 20 | 19 | 19 | 17 | 2.0 |

Microbiological studies

The full functioning of the soil and its biotic functions are largely determined by the microbial community. Microbiocenoses react very quickly to anthropogenic influences, which makes it possible to quickly identify the most vulnerable ecological zones. Therefore, soil microbial indicators are used for the purposes of environmental monitoring and assessment of the stability of the ecosystem as a whole, especially under various anthropogenic loads.

The microbial community of soils and desert sands is poorly studied, and little attention is paid to their role in self-purification of soil and sand of desert from petroleum hydrocarbons (Kharusi et al., 2016; Joy et al., 2017). Due to the low content of moisture and organic matter, a large temperature range, intensive solar irradiation and high alkalinity, the soil and sands of the desert are a severe environment for the life of microorganisms (An et al., 2013; Baubin et al., 2019; Pointing, Belnap, 2012; Schulze-Makuch et al., 2018; Quoreshi et al., 2019). Therefore, hydrocarbons in desert soils become even more resistant for degradation by microorganisms (Kharusi et al., 2016).

For the studied areas, the dependence of the total number of heterotrophic bacteria (TNH) and hydrocarbon oxidizing bacteria (HOB) on the content of HC in soils was noted (Figure 2). With the distance from the oil well and the decrease in the content of petroleum hydrocarbons (PH), the number of microorganisms in the soil decreased. This is probably due to the fact that in sandy soils that contain little organic matter, PH is practically the only source of organic matter, to whose content bacteria react with a change in abundance. Regular intake of small amounts of PH stimulates the development of the hydrocarbon oxidizing ability of microorganisms (Alrumman et al., 2015; Ebadi et al., 2018; Khan et al., 2018), at the same time, the salinity of soils polluted with hydrocarbons may, on the contrary, suppress the activity of bacteria (Gao et al., 2015). In order to undergo the processes of biodegradation of PH, the number of bacteria in the soil must be at least $10^3$ CFU/g (Khan et al., 2018). A smaller number of bacteria indicates a high content of HP, which have a toxic effect, blocking their enzymatic activity (Alrumman et al., 2015; Khan et al., 2018). Bacterial communities clearly reveal the “concentration limit” of pollution of hydrocarbons, below which microbial cenoses still cope with incoming hydrocarbons and stabilize the situation at 40–60 mg/kg of dry soil (Kuznetsova, Dzuban, 2001).

In the case of the studied saline soils, it can be assumed that the microbial community is on the verge of realizing the ability to self-purifying the soil and even a slight increase in the level of PH in the soil can lead to irreversible changes in the composition of the microbial community and, as a result, to chronic soil pollution.

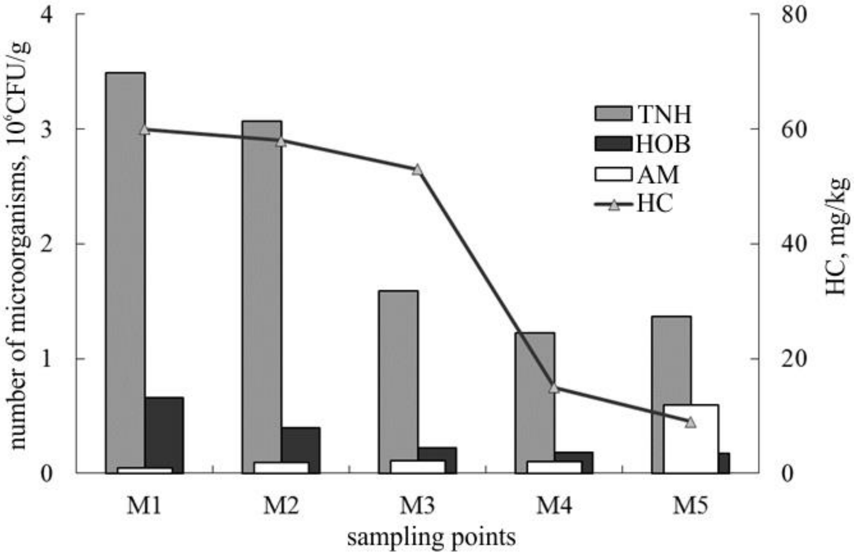


**Fig. 2.** The number of bacteria and the content of petroleum hydrocarbons (PH) in the soils of the Dzunbayan deposit: TNH – total number of heterotrophic bacteria, $1 \times 10^6$ CFU/g; HOB –number of hydrocarbon oxidizing bacteria, $1 \times 10^6$ CFU/g; AM – actinomycetes number, $1 \times 10^4$ CFU/g

An important indicator of the potential activity of microbial communities involved in the processes of soil self-purification is the content of HOB in it. It is believed that the proportion of HOB in the community of heterotrophic bacteria of background natural objects does not exceed the conditional level of 10 % (Patin, 2001). The proportion of HOB in the microbial communities of the studied soils ranged from 12.6 % in the soil sample M5 to 18.9 % in sample M1, which indicates their adaptation to pollution by hydrocarbons (Atlas, 1993; Peressutti et al., 2003; Zhang et al., 2012).

In addition to changes in the number of bacteria, soil microbiocenoses respond to environmental conditions by changing the ecological and trophic structure (Alrumman et al., 2015). The microbial community of the studied soils was distinguished by an abundance of pigmented colonies (Figure 3) and spore-forming bacteria. Bacteria pigments are secondary metabolites, they protect them from the action of visible light and UV rays (Órdenes-Aenishanslins et al., 2016). Pigmented forms of halophilic bacteria are often found in salt waters and soils (Rekadwad et al., 2017). Bacterial spores allow microorganisms to survive in unfavorable living conditions, they are resistant to elevated temperatures, radiation, chemicals, and tolerate the absence of moisture.

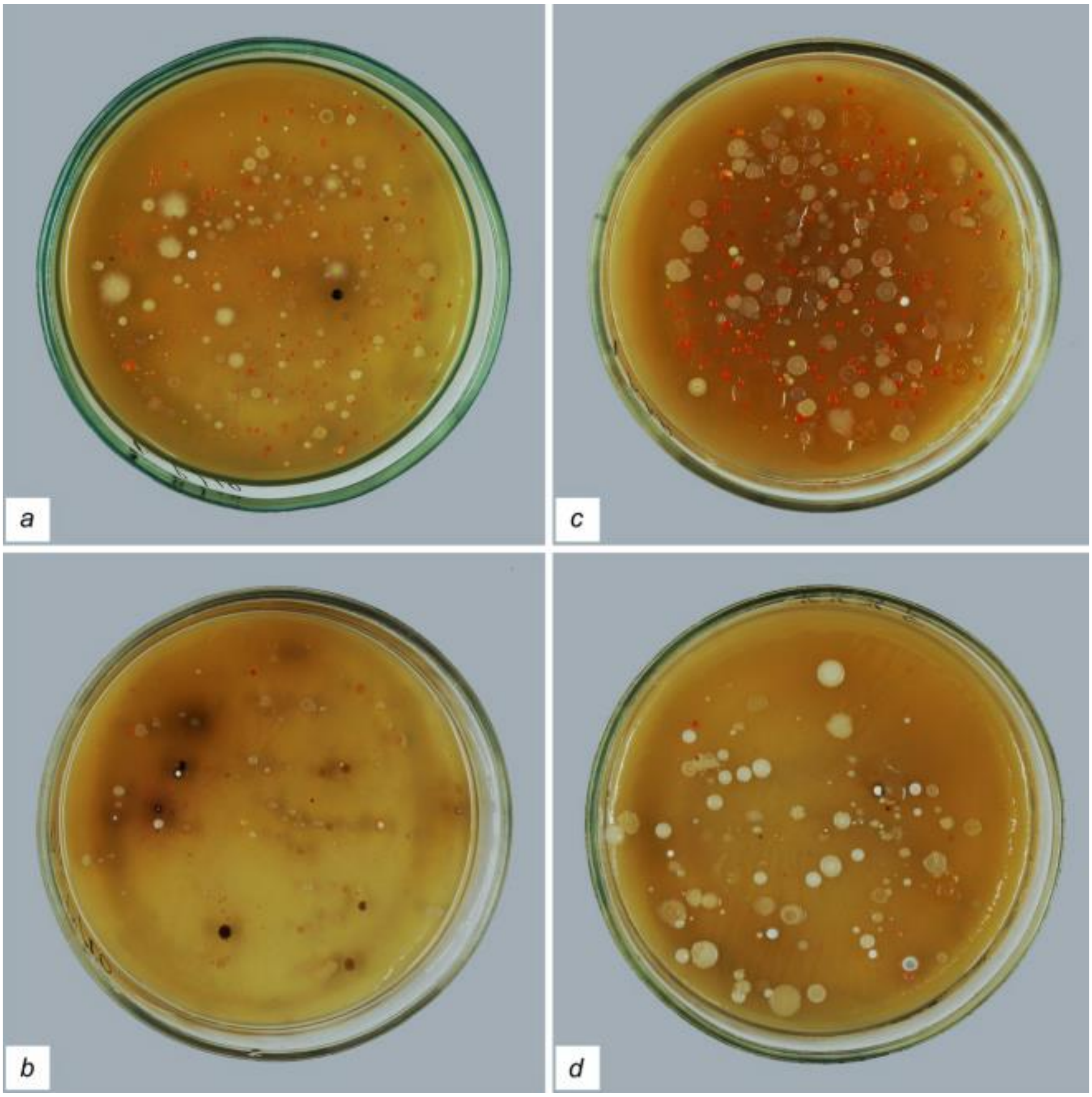


**Fig. 3**. Pigmented forms of heterotrophic soil microorganisms of the Dzunbayan deposit - carotenoids (pink, orange color), melanin (black, brown): *a*, *b* – colonies of microorganisms assimilating organic forms of nitrogen; *c*, *d* – colonies of microorganisms assimilating the mineral forms of nitrogen (5 and 30 m from the well, respectively)

Typical representatives of soil microbiocenosis are actinomycetes (AM). They predominate in dry alkaline soil (Bhatti et al., 2017). This group of microorganisms is actively developing in soils rich in organic matter, they do not tolerate changes in humidity, temperature and pollution by hydrocarbons (Bao et al., 2019). The number of AM in the studied soils was relatively small (on average $10^4$ CFU/g). As we approach the operating well, the number of actinomycetes in the soil decreased from a maximum of 11.9 $10^6$ CFU/g in sample M5 to a minimum of 0.97 $10^6$ CFU/g in sample M1, which indicates the inhibitory effect of hydrocarbons on actinomycetes. Microscopic fungi that are typical representatives of soil microbiocenosis of all climatic zones were not detected in the studied soil samples (Bao et al., 2019; Dighton, 1994; Grishkan, Nevo, 2010). Most likely, the main factor affecting the absence of micromycetes in soils is the pH of the environment. The pH values in the studied soils ranged from 8.15 to 8.67. Such pH values do not limit the development of most ecological-trophic groups of bacteria, but they are extremely unfavorable for micromycetes, preferring a slightly acid environment.

According the data of this paper, sustainable solutions need to embed short-term management in long-term landscape planning of oil production, transportation, and pollution prevention. It is necessary to move from excessive exploitation in combination with environmental protection, to sustainable use and management of the soil-water system (Keesstra et al., 2018) via transcendental Biogeosystem Technique methodology (Kalinitchenko et al., 2016). The proposed approach will help to implement LDN and to make a contribution to strategic world development (Keesstra et al., 2018).

## 4. Conclusion

The identified physico-chemical features of the studied soils of the desert zone (particle size, high pH values, salinity) together with specific climatic conditions and peculiarities of the oil composition of the Dzunbayan deposit (prevalence of heavy paraffin fractions) characterize their low potential for self-purification from pollution by hydrocarbons. However, a microbial community has developed in the soils, adapted to specific conditions: increased insolation, salinity, alkaline reactions of the environment and the presence of petroleum hydrocarbons. The content of hydrocarbon oxidizing bacteria in the microbial community of the soil (within 20 %) corresponds to the concentration boundary of pollution by hydrocarbons for the studied soils (up to 60 mg/kg) and even a slight increase in the level of petroleum hydrocarbons entering the soil can lead to irreversible changes in the composition of the microbial community and as a result – to chronic soil pollution. Sustainable solutions for planning the oil production, transportation, and pollution prevention will help to implement LDN and refine the currently not effective strategic world development principles.

## Литература


Вадюнина, Корчагина, 1973 – *Вадюнина А.Ф., Корчагина З.А.* (1973). Методы исследования физических свойств почв и грунтов. М.: Изд-во Высшая школа. 400 с.

ГН 2.1.7.20.41-06 – ГН 2.1.7.20.41-06 Предельно допустимые концентрации (ПДК) химических веществ в почве, Гигиенические нормативы.

ГОСТ 17.4.3.01-83 – ГОСТ 17.4.3.01-83. Почвы. Отбор проб для контроля загрязнения.

ГОСТ 17.4.4.02-84 – ГОСТ 17.4.4.02-84. Почвы. Методы отбора и подготовки проб для химического, бактериологического и гельминтологического анализа.

Кузнецова, Дубинина, 2001 – *Кузнецова И.А, Дзюбан А.Н.* (2001). Микробиологическая оценка последствий нефтяного загрязнения водоемов / *Современные проблемы гидробиологии Сибири: Тез. докл. Всесоюз. конф.* Томск. С. 123-124.

Патин, 2001 – *Патин С.А.* (2001). Нефть и экология континентального шельфа. М.: ВНИРО. 247 с.

ПНД Ф 16.1:2.2.22–98, 2005 – ПНД Ф 16.1:2.2.22–98 (2005). Методика выполнения измерений массовой доли нефтепродуктов в минеральных, органогенных, органно-минеральных почвах и донных отложениях методом ИК-спектрометрии. М.: Гос. ком. РФ по охране окружающей среды. 21 с.

Нетрусов и др., 2005 – *Нетрусов А.И., Егорова М.А., Захарчук Л.М.* и др. (2005). Практикум по микробиологии: Учебн. пособие для студ. высш. учеб. заведений. Под ред. А.И. Нетрусова. М.: Изд. Центр. «Академия». 608 с.

Рогозина, 2006 – *Рогозина Е.А.* (2006). Актуальные вопросы проблемы очистки нефтезагрязненных почв // *Нефтегазовая геология. Теория и практика,* 1: 1–11. DOI: 10.17353/2070-5379/48_2016

Серебряков, Кондратьев, 2012 – *Серебряков А.О., Кондратьев Ю.К.* (2012). Нефть Монголии: месторождения, физико-химический состав, запасы и добыча // *Геология, география и глобальная энергия*, 2(45): 21-26.

Уварова, 1989 – *Уварова В.И.* (1989). Современное состояние уровня загрязненности вод и грунтов Обь-Иртышского бассейна / *Сб. науч. тр. ГосНИОРХ,* 305. С. 23–33.

Alrumman et al., 2015 – *Alrumman S.A., Standing D.B., Paton G.I.* (2015). Effects of hydrocarbon contamination on soil microbial community and enzyme activity // *Journal of King Saud University – Science*, 27: 31–41. DOI: 10.1016/j.jksus.2014.10.001

An et al., 2013 – *An S., Couteau C., Luo F., Neveu J., DuBow M.S.* (2013). Bacterial Diversity of surface sand samples from the Gobi and Taklamaken deserts // *Microbial Ecology*, 66: 850-860. DOI: 10.1007/s00248-013-0276-2

Atlas, 1993 – *Atlas R.M.* (1993). Bacteria and bioremediation of marine oil spills // *Oceanus*, 36: 71-80.

Bao et al., 2019 – *Bao T., Zhao Y., Yang X., Ren W., Wang S.* (2019). Effects of disturbance on soil microbial abundance in biological soil crusts on the Loess Plateau, China // *Journal of Arid Environments*, 163: 59-67.

Baubin et al., 2019 – *Baubin C., Farrell A.M., Šťovíček A., Ghazaryan L., Giladi I., Gillor O.* (2019). Seasonal and spatial variability in total and active bacterial communities from desert soil // *Pedobiologia – Journal of Soil Ecology,* 74: 7-14.

Bhatti et al., 2017 – *Bhatti A.A., Haq S., Bhat R.A.* (2017). Actinomycetes benefaction role in soil and plant health // *Microbial Pathogenesis*, 111: 458–467. DOI: 10.1016/j.micpath.2017.09.036

Dighton, 1994 – *Dighton J.* (1994). Analysis of micromycete communities in soil: a critique of methods // *Mycological Research*, 98: 796–798. DOI: 10.1016/S0953-7562(09)81058-7

Ebadi et al., 2018 – *Ebadi A., Sima N.A.K., Olamaee M., Hashemi M., Nasrabadi R.G.* (2018). Remediation of saline soils contaminated with crude oil using the halophyte Salicornia persica in conjunction with hydrocarbon-degrading bacteria // *Journal of Environmental Management*, 219: 260–268. DOI: doi.org/10.1016/j.jenvman.2018.04.115

Fraunhofer, 1817 – *Fraunhofer J.* (1817). Bestimmung des Brechungs- und des Farbenzerstreungs-Vermögens verschiedener Glasarten, in Bezug auf die Vervollkommnung achromatischer Fernröhre // *Annalen der Physik*, 56(7): 264-313.

Gao et al., 2015 – *Gao Y., Wang J., Guo S., Hu Y., Li T., Mao R., Zeng D.* (2015). Effects of salinization and crude oil contamination on soil bacterial community structure in the Yellow River Delta region, China // *Applied Soil Ecology*, 86: 165–173. DOI: 10.1016/j.apsoil.2014.10.011

Grishkan, Nevo, 2010 – *Grishkan I., Nevo E.* (2010). Spatiotemporal distribution of soil microfungi in the Makhtesh Ramon area, central Negev desert, Israel // *Fungal Ecology*, 3: 326-337. DOI: 10.1016/j.funeco.2010.01.003

He et al., 2014 – *He B., Cai Y., Ran W., Jiang H.* (2014). Spatial and seasonal variations of soil salinity following vegetation restoration in coastal saline land in eastern China // *CATENA*, 118: 147–153. doi: 10.1016/j.catena.2014.02.007

Jambaajamts, Norjmaa, 1997 – *Jambaajamts B., Norjmaa L.* (1997). Meteorological Observations Manual 38: Quality Control Manual of Meteorological Observations (in Mongolian). NAMHEM: Ulaanbaatar.

Joy et al., 2017 – *Joy S., Rahman P.K.S.M., Sharma S.* (2017). Biosurfactant production and concomitant hydrocarbon degradation potentials of bacteria isolated from extreme and hydrocarbon contaminated environments // *Chemical Engineering Journal*, 317: 232–241. doi: 10.1016/j.cej.2017.02.054

Keesstra et al., 2016 – *Keesstra S.D., Bouma J., Wallinga J., Tittonell P., Smith P., Cerdà A., Montanarella L., Quinton J.N., Pachepsky Y., van der Putten W.H., Bardgett R.D., Moolenaar S., Mol G., Jansen B., Fresco L.O.* (2016). The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals. *Soil*, 2: 111-128. DOI: 10.5194/soil-2-111-2016

Keesstra et al., 2018 – *Keesstra S., Mol G., De Leeuw J., Okx J., Molenaar C., De Cleen M., Visser S.* (2018). Soil-related sustainable development goals: Four concepts to make land degradation neutrality and restoration work. *Land*, 7(4), 133. DOI: 10.3390/land7040133

Khan et al., 2018 – *Khan M.A.I., Biswas B., Smith E., Naidu R., Megharaj M.* (2018). Toxicity assessment of fresh and weathered petroleum hydrocarbons in contaminated soil (a review) // *Chemosphere*, 212: 755–767. DOI: 10.1016/j.chemosphere.2018.08.094

Kharusi et al., 2016 – *Kharusi S.A., Abed R.M.M., Dobretsov S.* (2016). EDTA addition enhances bacterial respiration activities and hydrocarbon degradation in bioaugmented and non-bioaugmented oil-contaminated desert soils // *Chemosphere*, 147: 279-286.

Li et al., 2011 – *Li C., Li Y., Ma J.* (2011). Spatial heterogeneity of soil chemical properties at fine scales induced by Haloxylon ammodendron (Chenopodiaceae) plants in a sandy desert // *Ecological Research*, 26: 385-394. DOI: 10.1007/s11284-010-0793-0

Liu et al., 2016 – *Liu B., Jin H., Sun Z., Zhao S.* (2016). Geochemical weathering of aeolian sand and its palaeoclimatic implications in the Mu Us Desert, northern China, since the Late Holocene // *Journal of Arid Land*, 8: 647–659. DOI: 10.1007/s40333-016-0014-y

Órdenes-Aenishanslins et al., 2016 – *Órdenes-Aenishanslins N., Anziani-Ostuni G., Vargas-Reyes M., Alarcón J., Tello A., Pérez-Donoso J.M.* (2016). Pigments from UV-resistant Antarctic bacteria as photosensitizers in dye sensitized solar cells // *Journal of Photochemistry and Photobiology B: Biology*, 162: 707–714. DOI: 0.1016/j.jphotobiol.2016.08.004

Peressutti et al., 2003 – *Peressutti S.R., Alvarez H.M., Pucci O.H.* (2003). Dynamics of hydrocarbon-degrading bacteriocenosis of an experimental oil pollution in Patagonian soil // *International Biodeterioration & Biodegradation*, 52: 21-30. DOI: 10.1016/S0964-8305(02)00102-6

Pointing, Belna, 2012 – *Pointing S.B., Belnap J.* (2012). Microbial colonization and controls in dryland systems // *Nature Reviews Microbiology*, 10: 551-562. DOI: 10.1038/nrmicro2831

Quoreshi et al., 2019 – *Quoreshi A.M., Suleiman M.K., Kumar V., Manuvel A.J., Sivadasan M.T., Islam M.A., Khasa D.P.* (2019). Untangling the bacterial community composition and structure in selected Kuwait desert soils // *Applied Soil Ecology*, 138: 1-9. DOI: 10.1016/j.apsoil.2019.02.006

Rekadwad, Khobragade, 2017 – *Rekadwad B.N., Khobragade C.N.* (2017) Morphotypes and pigment profiles of halophilic bacteria: Practical data useful for novelty, taxonomic categorization and for describing novel species or new taxa // *Data in Brief*, 13: 609-619. DOI: 10.1016/j.dib.2017.06.039

Schulze-Makuch et al., 2018 – *Schulze-Makuch D., Wagner D., Kounaves S.P., Mangelsdorf K., Devine K.G., Vera J.-P., Schmitt-Kopplin P., Grossart H.-P., Parro V., Kaupenjohann M., Galy A., Schneider B., Airo A., Frösler J., Davila A.F., Arens F.L., Cáceres L., Cornejo F.S., Carrizo D., Dartnell L., DiRuggiero J., Flury M., Ganzert L., Gessner M.O., Grathwohl P., Guan L., Heinz J., Hess M., Keppler F., Maus D., McKay C.P., Meckenstock R.U., Montgomery W., Oberlin E.A., Probst A.J., Sáenz J.S., Sattler T., Schirmack J., Sephton M.A., Schloter M., Uhl J., Valenzuela B., Vestergaard G., Wörmer L., Zamorano P.* (2018). Transitory microbial habitat in the hyperarid Atacama Desert // *PNAS*, 115: 2670-2675. DOI: 10.1073/pnas.1714341115

Shein et al., 2017 – *Shein E.V., Kharitonova G.V., Bayasgalan Amgalan, Gantumur Sambuu, Krutikova V.O., Kharitonov E.V.* (2017). Salt Neoformations in Soils of Central Mongolia // *Biogeosystem Technique*, 4(1): 66–81. DOI: 10.13187/bgt.2017.1.66

Wolform, 2011 – *Wolform R.L.* (2011). The language of particle size // *J. GXP Compliance,* 15(2): 10-20.

Zhang et al., 2012 – *Zhang D., Mörtelmaier C., Margesin R.* (2012). Characterization of the bacterial archaeal diversity in hydrocarbon-contaminated soil // *Science of The Total Environment*, 421-422: 184–196. DOI: 10.1016/j.scitotenv.2012.01.043

**References**

Alrumman et al., 2015 – *Alrumman S.A., Standing D.B., Paton G.I.* (2015). Effects of hydrocarbon contamination on soil microbial community and enzyme activity. *Journal of King Saud University – Science*, 27: 31-41. DOI: 10.1016/j.jksus.2014.10.001

An et al., 2013 – *An S., Couteau C., Luo F., Neveu J., DuBow M.S.* (2013). Bacterial Diversity of surface sand samples from the Gobi and Taklamaken deserts. *Microbial Ecology*, 66: 850-860. DOI: 10.1007/s00248-013-0276-2

Atlas, 1993 – *Atlas R.M.* (1993). Bacteria and bioremediation of marine oil spills. Oceanus, 36: 71-80.

Bao et al., 2019 – *Bao T., Zhao Y., Yang X., Ren W., Wang S.* (2019). Effects of disturbance on soil microbial abundance in biological soil crusts on the Loess Plateau, China. *Journal of Arid Environments*, 163: 59-67.

Baubin et al., 2019 – *Baubin C., Farrell A.M., Šťovíček A., Ghazaryan L., Giladi I., Gillor O.* (2019). Seasonal and spatial variability in total and active bacterial communities from desert soil. *Pedobiologia – Journal of Soil Ecology*, 74: 7-14.

Bhatti et al., 2017 – *Bhatti A.A., Haq S., Bhat R.A.* (2017). Actinomycetes benefaction role in soil and plant health. *Microbial Pathogenesis*, 111: 458-467. DOI: 10.1016/j.micpath.2017.09.036

Dighton, 1994 – *Dighton J.* (1994). Analysis of micromycete communities in soil: a critique of methods. *Mycological Research*, 98: 796–798. DOI: 10.1016/S0953-7562(09)81058-7

Ebadi et al., 2018 – *Ebadi A., Sima N.A.K., Olamaee M., Hashemi M., Nasrabadi R.G.* (2018). Remediation of saline soils contaminated with crude oil using the halophyte Salicornia persica in conjunction with hydrocarbon-degrading bacteria. *Journal of Environmental Management*, 219: 260–268. DOI: doi.org/10.1016/j.jenvman.2018.04.115

END F 16.1:2.2.22–98, 2005 – END F 16.1:2.2.22–98. (2005). Methods of measurements of mass fraction of petroleum products in mineral, organogenic, organ-mineral soils and sediments by IR spectrometry. M.: State Com. of RF. for Env. Protection. 21 p.

Fraunhofer, 1817 – *Fraunhofer J.* (1817). Bestimmung des Brechungs- und des Farbenzerstreungs-Vermögens verschiedener Glasarten, in Bezug auf die Vervollkommnung achromatischer Fernröhre. *Annalen der Physik*, 56(7): 264-313.

Gao et al., 2015 – *Gao Y., Wang J., S. Guo, Hu Y., Li T., Mao R., Zeng D.* (2015). Effects of salinization and crude oil contamination on soil bacterial community structure in the Yellow River Delta region, China. *Applied Soil Ecology*, 86: 165–173. DOI: 10.1016/j.apsoil.2014.10.011

Grishkan, Nevo, 2010 – *Grishkan I., Nevo E.* (2010). Spatiotemporal distribution of soil microfungi in the Makhtesh Ramon area, central Negev desert, Israel. *Fungal Ecology*, 3: 326-337. doi: 10.1016/j.funeco.2010.01.003

He et al., 2014 – *He B., Cai Y., Ran W., Jiang H.* (2014). Spatial and seasonal variations of soil salinity following vegetation restoration in coastal saline land in eastern China. *CATENA*, 118: 147-153. DOI: 10.1016/j.catena.2014.02.007

HS 2.1.7.20.41-06 – HS 2.1.7.20.41-06 Maximum allowable concentrations (MACs) for chemicals in the soil. Hygienic standards.

IS 17.4.3.01-83 – IS 17.4.3.01-83. Soils. Sampling for pollution control.

IS 17.4.4.02-84 – IS 17.4.4.02-84. Soils. Methods for sampling and sample preparation for chemical, bacteriological and helminthological analysis.

Jambaajamts, Norjmaa, 1997 – *Jambaajamts B., Norjmaa L.* (1997). Meteorological Observations Manual 38: Quality Control Manual of Meteorological Observations (in Mongolian). NAMHEM: Ulaanbaatar.

Joy et al., 2017 – *Joy S., Rahman P.K.S.M., Sharma S.* (2017). Biosurfactant production and concomitant hydrocarbon degradation potentials of bacteria isolated from extreme and hydrocarbon contaminated environments. *Chemical Engineering Journal*, 317: 232-241. DOI: 10.1016/j.cej.2017.02.054

Kalinitchenko et al., 2016 – *Kalinitchenko Valery, Abdulmalik Batukaev, Ali Zarmaev, Viktor Startsev, Vladimir Chernenko, Zaurbek Dikaev, Svetlana Sushkova* (2016). Biogeosystem technique as the way to certainty of soil, hydrosphere, environment and climate. EGU General Assembly. Vienna, 2016. Geophysical Research Abstracts. Vol. 18, EGU2016-3419.

Keesstra et al., 2016 – *Keesstra S.D., Bouma J., Wallinga J., Tittonell P., Smith P., Cerdà A., Montanarella L., Quinton J.N., Pachepsky Y., van der Putten W.H., Bardgett R.D., Moolenaar S., Mol G., Jansen B., Fresco L.O.* (2016). The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals. *Soil*, 2: 111-128. DOI: 10.5194/soil-2-111-2016

Keesstra et al., 2018 – *Keesstra S., Mol G., De Leeuw J., Okx J., Molenaar C., De Cleen M., Visser S.* (2018). Soil-related sustainable development goals: Four concepts to make land degradation neutrality and restoration work. *Land*, 7(4), 133. DOI: 10.3390/land7040133

Khan et al., 2018 – *Khan M.A.I., Biswas B., Smith E., Naidu R., Megharaj M.* (2018). Toxicity assessment of fresh and weathered petroleum hydrocarbons in contaminated soil (a review). *Chemosphere*, 212: 755-767. DOI: 10.1016/j.chemosphere.2018.08.094

Kharusi et al., 2016 – *Kharusi S.A., Abed R.M.M., Dobretsov S.* (2016). EDTA addition enhances bacterial respiration activities and hydrocarbon degradation in bioaugmented and non-bioaugmented oil-contaminated desert soils. *Chemosphere*, 147: 279-286.

Kuznetsova, Dzuban, 2001 – *Kuznetsova I.A., Dzuban A.N.* (2001). Microbiological evaluation of the impact of oil pollution on reservoirs. Modern problems of hydrobiology of Siberia: Tez. Rep. Vsesojuz. conf. Tomsk. pp. 123-124.

Li et al., 2011 – *Li C., Li Y., Ma J.* (2011). Spatial heterogeneity of soil chemical properties at fine scales induced by Haloxylon ammodendron (Chenopodiaceae) plants in a sandy desert. *Ecological Research*, 26: 385-394. DOI: 10.1007/s11284-010-0793-0

Liu et al., 2016 – *Liu B., Jin H., Sun Z., Zhao S.* (2016). Geochemical weathering of aeolian sand and its palaeoclimatic implications in the Mu Us Desert, northern China, since the Late Holocene. *Journal of Arid Land*, 8: 647-659. DOI: 10.1007/s40333-016-0014-y

Netrusov et al., 2005 – *Netrusov A.I., Yegorova M.A., Zaharchuk L.M. et al.* (2005). Workshop on microbiology (ed. Netrusov A.I.) M.: Izd. Centre «Akademiya». 608 p.

Órdenes-Aenishanslins et al., 2016 – *Órdenes-Aenishanslins N., Anziani-Ostuni G., Vargas-Reyes M., Alarcón J., Tello A., Pérez-Donoso J.M.* (2016). Pigments from UV-resistant Antarctic bacteria as photosensitizers in dye sensitized solar cells. *Journal of Photochemistry and Photobiology B: Biology*, 162: 707-714. DOI: 0.1016/j.jphotobiol.2016.08.004

Patin, 2001 – *Patin S.A.* (2001). Oil and ecology of the continental shelf. M.: VNIRO. 247 p.

Peressutti et al., 2003 – *Peressutti S.R., Alvarez H.M., Pucci O.H.* (2003). Dynamics of hydrocarbon-degrading bacteriocenosis of an experimental oil pollution in Patagonian soil. International Biodeterioration & Biodegradation, 52: 21-30. DOI: 10.1016/S0964-8305(02)00102-6

Pointing, Belna, 2012 – *Pointing S.B., Belnap J.* (2012). Microbial colonization and controls in dryland systems. *Nature Reviews Microbiology*, 10: 551-562. DOI: 10.1038/nrmicro2831

Quoreshi et al., 2019 – *Quoreshi A.M., Suleiman M.K., Kumar V., Manuvel A.J., Sivadasan M.T., Islam M.A., Khasa D.P.* (2019). Untangling the bacterial community composition and structure in selected Kuwait desert soils. *Applied Soil Ecology*, 138: 1-9. DOI: 10.1016/j.apsoil.2019.02.006

Rekadwad, Khobragade, 2017 – *Rekadwad B.N., Khobragade C.N.* (2017). Morphotypes and pigment profiles of halophilic bacteria: Practical data useful for novelty, taxonomic categorization and for describing novel species or new taxa. *Data in Brief*, 13: 609-619. DOI: 10.1016/j.dib.2017.06.039

Rogozina, 2006 – *Rogozina E.A.* (2006). Topical issues of purification of oil contaminated soil. *Oil and gas geology. Theory and practice*, 1: 1-11. DOI: 10.17353/2070-5379/48_2016

Schulze-Makuch et al., 2018 – *Schulze-Makuch D., Wagner D., Kounaves S.P., Mangelsdorf K., Devine K.G., Vera J.-P., Schmitt-Kopplin P., Grossart H.-P., Parro V., Kaupenjohann M., Galy A., Schneider B., Airo A., Frösler J., Davila A.F., Arens F.L., Cáceres L., Cornejo F.S., Carrizo D., Dartnell L., DiRuggiero J., Flury M., Ganzert L., Gessner M.O., Grathwohl P., Guan L., Heinz J., Hess M., Keppler F., Maus D., McKay C.P., Meckenstock R.U., Montgomery W., Oberlin E.A., Probst A.J., Sáenz J.S., Sattler T., Schirmack J., Sephton M.A., Schloter M., Uhl J., Valenzuela B., Vestergaard G., Wörmer L., Zamorano P.* (2018). Transitory microbial habitat in the hyperarid Atacama Desert. *PNAS*, 115: 2670-2675. DOI: 10.1073/pnas.1714341115

Serebriakov, Kondratiev, 2012 – *Serebriakov A.O., Kondratiev Yu.K.* (2012). Mongolian oil: physical and chemical structure, resources and ways of oil output. *Geology, geography and global energy*, (45): 21-26.

Shein et al., 2017 – *Shein E.V., Kharitonova G.V., Bayasgalan Amgalan, Gantumur Sambuu, Krutikova V.O., Kharitonov E.V.* (2017). Salt Neoformations in Soils of Central Mongolia. *Biogeosystem Technique*, 4(1): 66-81. DOI: 10.13187/bgt.2017.1.66

Uvarova, 1989 – *Uvarova V.I.* (1989). Current status of pollution in waters and soils the Ob-Irtysh basin. Coll. researcher. tr. GosNIORH. 305: 23-33.

Vadjunina, Korchagina, 1973 – *Vadjunina A.F., Korchagina Z.A.* (1973). Methods of research on the physical properties of soils. Vysshaya Shkola: Moscow. 400 p.

Villacís et al., 2016 – *Villacís J., Casanoves F., Hang S., Keesstra S., Armas C.* (2016). Selection of forest species for the rehabilitation of disturbed soils in oil fields in the Ecuadorian Amazon. *Science of the Total Environment*, 566–567: 761–770. DOI: https://doi.org/10.1016/j.scitotenv.2016.05.102

Wolform, 2011 – *Wolform R.L.* (2011). The language of particle size. *J. GXP Compliance*, 15(2): 10-20.

Zhang et al., 2012 – *Zhang D., Mörtelmaier C., Margesin R.* (2012). Characterization of the bacterial archaeal diversity in hydrocarbon-contaminated soil. *Science of The Total Environment*, 421–422: 184-196. DOI: 10.1016/j.scitotenv.2012.01.043

# Биогеохимическая характеристика почв района нефтедобычи Дзунбаян (Восточная Монголия)

Гантумур Самбуу [a], Людмила Александровна Гаретова [b], Елена Львовна Имранова [b], Ольга Александровна Кириенко [b], Наталья Константиновна Фишер [b], Гантумур Халиун [a, c], Галина Владимировна Харитонова [b, *]

[a] Монгольский государственный университет науки и технологии, Монголия
[b] Институт Водных и Экологических Проблем, Дальневосточное отделение РАН, Хабаровск, Российская Федерация
[c] Пекинский университет нефти, КНР

**Аннотация.** Представлены данные по гранулометрическому составу, содержанию химических компонентов и численности микроорганизмов в почвах участка нефтедобычи Дзунбаян (Восточное Гоби). Исследуемые почвы характеризуются бимодальным распределением частиц: основная фракция – грубый песок (200–2000 мкм), она составляет от 40 до 60 %. Ей сопутствует фракция тонкой пыли (2–20 мкм), содержание которой достигает 17 %. В почвах выявлено повышенное содержание хрома, меди, стронция, рубидия, цезия и мышьяка, отражающее геохимическую специфику данной геологической провинции. Вследствие аридного характера климата исследуемые почвы имеют щелочную реакцию среды pH 8.2–8.7. Незасоленные на контрольных участках рядом со скважиной они сильно засолены (содержание солей достигает 0.7–1.2%), что обусловлено используемыми технологиями добычи нефти. Содержание нефтяных углеводородов (НУ) в почвах исследуемого участка варьирует от 9 до 60 мг/кг при максимуме вблизи эксплуатационной скважины. Микробное сообщество почв по ряду признаков характеризуется высокой степенью адаптации к условиям аридной зоны, солености, высоким значениям pH, в то же время эти условия ограничивают развитие типичных представителей почвенных микробоценозов – актиномицетов и в большей степени микроскопических грибов. Общая численность гетеротрофных бактерий (ОЧГ) в исследованных почвенных образцах варьировала в пределах 1.22–3.49 $10^6$ КОЕ/г сухой почвы, доля нефтеокисляющих бактерий (НОБ) составляла 12.6–18.9 % от ОЧГ. Содержание НОБ в микробном сообществе почвы (в пределах 20 %) соответствует концентрационной границе нефтяного загрязнения для исследованных почв (до 60 мг/кг), что указывает на то, что микробное сообщество находится на грани реализации способности к самоочищению почвы. Выявленные физико-химические особенности исследованных почв пустынной зоны (доминирование песчаных фракций, высокие значения pH, соленость) в совокупности со специфическими климатическими условиями и особенностями состава нефти месторождения Дзунбаян (преобладание тяжелых парафиновых фракций) характеризуют их низкую потенциальную способность к самоочищению от нефтяного загрязнения.

**Ключевые слова**: нефтедобыча, почвы, осолоненность, загрязнение, углеводороды, бактерии, Монголия.

[*] Корреспондирующий автор
Адреса электронной почты: gkharitonova@mail.ru (Г.В. Харитонова)

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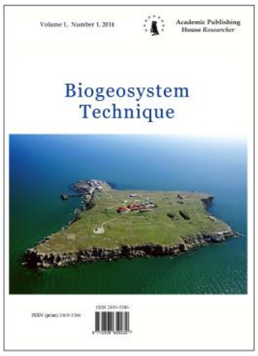


# Validation of HYDRUS-1D for Predicting of Soil Moisture Content with Hysteresis Effect

Evgeny V. Shein [a, b], Ahmed Y. Mady [a, c, *], Leonid I. Il'in [d]

[a] Lomonosov Moscow State University, Russian Federation
[b] Dokuchaev Soil Science Institute, Russian Federation
[c] Ain shams university, Faculty of Agriculture, Soil science Department, Egypt
[d] Vladimir Research Agricultural Institute, Russian Federation

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**Abstract**

HYDRUS-1D program is commonly used to estimate soil moisture, solute, and temperature flow in saturated and unsaturated zone under different initials and boundary conditions. The aim of the work was to validate the efficiency of HYDRUS-1D program for predicting soil moisture and temperature dynamics with hysteresis using HYDRUS-1D for clay loam Albic Glossic Retisols (Lomic, Cutanic) soils. The efficiency of HYDRUS-1D was determined by comparing field experiment measurements of soil moisture and temperature dynamics with its calculated soil moisture and temperature dynamics by HYDRUS-1D based on soil physical properties. The distribution and the values of measured soil moisture and temperature dynamics in the field were close to its calculated soil moisture and temperature using HYDRUS-1D with hysteresis effect of soil water retention. HYDRUS-1D program can be used for simulation of soil moisture and temperature dynamics, but more accurate calculations are possible when using the hysteresis effect of soil moisture retention curve for Clay loam and silty Clay loam soils.

**Keywords:** water retention, irrigation, field experiments, experimental and modelling data, water and temperature dynamics.

## 1. Introduction

Soil moisture and temperature dynamics are forming the soil hydro and thermal regimes. It is used for modeling water and heat flux in the soil, plant production, evapotranspiration, irrigation and drainage designs, groundwater contamination, soil evaluation, soil biota, and environmental processes. Although the field measurements of soil moisture and temperature regimes are accurate, they are time-consuming and costly. The dynamics of soil moisture and temperature may be calculated using mathematical models, which are involving the quantitative description of the hydro and thermal-physical properties based on fundamental of soil physical parameters as predictors. The information of soil hydro and thermal-physical properties is

* Corresponding author
E-mail addresses: ahmed_mady@agr.asu.edu.eg (A. Yehia Mady)

required to accurately predict modeling soil moisture and temperature dynamics (Mady, Shein, 2018; Shein, Mady, 2016). Several methods used for estimation and measurement of soil hydro and thermal-physical properties, they have divided into direct and indirect methods. Some attempts have been made to predict indirectly soil hydro and thermal-physical properties from the easily available soil physical parameters using mathematical models and pedotransfer functions (PTFs) (Mady, Shein, 2018). The majority of PTFs can be estimated from proxy variables of soil physical properties those are easily available, such as soil texture components, organic matter content, and soil bulk density (Jarvis et al., 2013; Jorda et al., 2015; Shein et al., 2015).

HYDRUS-1D, a software package for simulating water, heat and solute movement in one-dimensional variably saturated and unsaturated media. The software consists of the HYDRUS computer program, and the HYDRUS-1D interactive graphics-based user interface. The HYDRUS program numerically solves the Richards' equation for variably saturated water flow and convection-dispersion type equations for heat and solute transport. The flow equation incorporates a sink term to account for water uptake by plant roots. The flow equation may also consider dual-porosity-type flow with a fraction of water content being mobile, and fraction immobile (Gerke, van Genuchten, 1993a, 1993b; Simunek et al., 2008). The heat transport equation considers transport due to conduction and convection with flowing water (Simunek et al., 2001, 2003). So it is important to evaluate the efficiency of HYDRUS-1D program for forecasting soil moisture and temperature dynamics for clay soil of podzolic genesis.

## 2. Materials and methods

The field experiment was carried out in Albic Glossic Retisols (Lomic, Cutanic) (WRB, 2014), Moscow region, Russia, during the period from 2 to 7 August, 2017. The dataset of soil moisture, soil potential, soil temperature and meteorological data was collected and measured for program HYDRUS-1D at soil depths 10, 15, 20, 30, 40, 50 and 60 cm. The cylindrical monolith of Albic Glossic Retisols was dug, with a diameter of 1 m and a height of 60 cm. Moreover, the walls of the monolith were isolated by foam from the horizontal flow of soil moisture and heat movement in Albic Glossic Retisols.

2.1 Soil moisture dynamics

a) Soil moisture was measured daily at soil depths (0, 10, 20, 30, 40, 50, and 60 cm) using direct method (weight method)

b) Soil water pressure was measured daily using the digital tensiometers at soil depths (0, 10, 15, 20, 30, 40, 50, and 60 cm) for 3 days before and after irrigation.

2.2. Soil temperature dynamics

a) Soil temperature was measured daily using digital temperature sensors or digital recorder (EC LERK-USB-RHT-K1), with isolated from the horizontal flow soil walls monolith of Albic Glossic Retisols, at soil depths (0, 10, 15, 20, 30, 40, 50, and 60 cm).

2.3. Efficiency of program HYDRUS-1D

In order to estimate the efficiency of program HYDRUS-1D for prediction soil moisture and temperature dynamics in Albic Glossic Retisol, its results were compared with the field experiment. The dataset of soil water content, soil temperature, and meteorological data was measured for program HYDRUS-1D at soil depths 10, 15, 20, 30, 40, 50 and 60 cm. When reaching moisture equilibrium in the process of draining the monolith (according to long-standing tensiometric observations), the soil moisture content was determined by drilling. The density of the soil was determined with repetition and presented in Table 1.

**Table 1.** Statistical characteristics of some soil properties (Mady, Shein, 2018)

| Soil properties | Medium | Min | Max | Standard deviation |
|---|---|---|---|---|
| Sand, 2-0,05 mm, % | 5.50 | 1.80 | 8.91 | 2.01 |
| Silt, 0,002-0,05 mm, % | 67.58 | 59.01 | 76.35 | 4.96 |
| Clay <0,002 mm, % | 26.90 | 17.65 | 35.29 | 5.50 |
| Soil density, g/cm3 | 1.35 | 1.19 | 1.49 | 0.10 |
| Organic matter content, % | 1.37 | 0.34 | 2.97 | 0.77 |

Soil moisture hysteresis was determined in spesial laboratory experiment with tensimeters in the range of soil water pressure form −30 to −800 cm on soil undistributed samples for the layers 0–10, 10–30, 30–40 and 40–60 cm (Shein, Mady, 2018). During field experiment meteorological data for the calculation of evaporation from the surface soil was measured for the HYDRUS-1D program from 2 to 7 August 2017 based on the average of daily temperature, wind speed, and relative humidity using the Penman-Monteith equation. The upper and lower boundary conditions for soil moisture and temperature are shown in Table 2 for modeling soil moisture and temperature dynamics which was used in HYDRUS-1D program.

a) Soil moisture dynamics: Pre-processing for HYDRUS-1D program depended on the parameters of van Genuchten (1980) ($\theta r$, $\theta s$, $\alpha_d$ and n) which were determined based on the particle size distribution and soil bulk density. Also, water flow simulation was determined with hysteresis based on the model of Kool and Parker (1987), $\alpha_w$ for the wetting branch.

b) Soil temperature dynamics: Pre-processing for HYDRUS-1D program depended on the parameters of Chung and Horton (1987) which were determined based on the soil the particle size distribution (soil texture).

**Table 2.** Boundary conditions for soil water and heat transport

| Parameter | Boundary condition | |
|---|---|---|
| Water flow | Upper | Atmospheric BC with surface layer. Evapotranspiration was calculated the average of daily temperature, wind speed, and relative humidity using the Penman-Monteith equation. |
| | Lower | Free drainage |
| Heat transport | Upper | Soil temperature BC (measured, on the surface) |
| | Lower | Soil temperature BC (constant, jn the depth 60 cv) |

## 3. Results and discussion

3.1. Simulation soil moisture dynamics

As the result of the conducted field experiment with artificial irrigation of the dried monolith of Albic Glossic Retisols, the dynamics of soil moisture and temperature were measured, and calculations of these dynamics under really initial and boundaries conditions were estimated. Figure 1 shows the differences of real and calculated soil moisture without and with hysteresis. Figure 2 shows the distributions of measured soil moisture in the field were usually different from its calculated soil moisture by the HYDRUS-1D program. However, the difference between measured soil moisture in the field and its calculated soil moisture by program HYDRUS-1D was small at soil depths (10, 20, 30, 40) cm, whereas those difference were large at bigger soil depths (50 and 60) cm as Figure 3. The reason of that due to the lower boundary condition was free drainage at soil depth 60 cm, but those boundary conditions are usually used at depths bigger than that, reach to 150 cm.

3.2. Simulation soil moisture dynamics with hysteresis

The differences on Figure 1 shows the difference between calculated soil moisture without hysteresis and its calculated soil moisture with hysteresis by HYDRUS-1D were small at soil depths (10, 20, 40 and 60) cm, but the difference was larger at shallow soil depths 20 and 40 cm, especially in case soil moisture calculation without hysteresis of soil moisture retention. The differences on Figure 1 are usually real but less than 0,01cm$^3$/cm$^3$. The reason for the difference related to the hysteresis degree which depended on, the value of soil bulk density and the percentage of clay. The higher degree of hysteresis was at the surface soil layers, but the lower degree of hysteresis was at soil depth 60 cm.

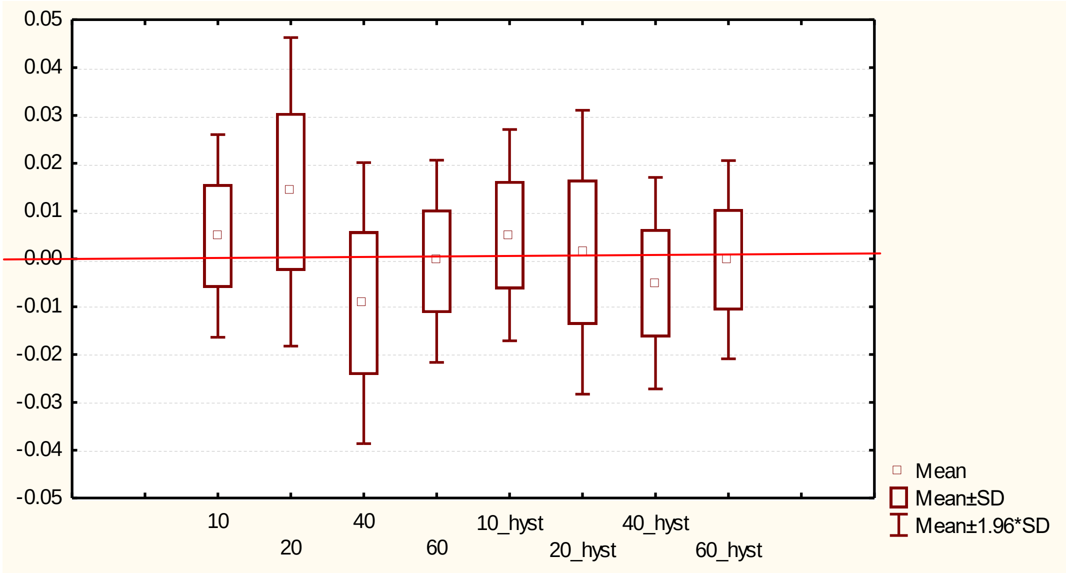



**Fig. 1.** Statistics of the difference between measured and calculated soil moisture content (by volume) using program HYDRUS-1S for the depths 10, 20, 40 and 60 and calculated with soil moisture hysteresis (10_hyst, 20_hyst, 40_hyst and 60_hyst) of agro-podzolic soil

HYDRUS-1D is commonly used for simulation soil moisture dynamics with hysteresis based on the model of Kool and Parker (1987) $\alpha_w = 2\alpha_d$. The above calculations and the good agreement between the calculated and real values of humidity indicate in favor of this dependence. However, in some cases, and in some soils, a different model can be used on the same theoretical basis. Apparently, for each soil in study, the hysteresis of water retention can be described by close regression functions of the bubbling pressure of the drying and wetting curves. For example, for clay structured Albic Glossic Retisols the hysteresis can be calculated on the model $\alpha_w = 0.13 + \alpha_d$, (Shein, Mady, 2018).

3.3. Simulation soil temperature dynamics

It is known that water and thermal regimes are closely related. Therefore, an adequate water regime estimation in the HYDRUS-1D program with the use of hysteresis data should be adequately reflected in the restoration of the temperature regime. Figure 2 shows the differences between measured in the field and calculated by program HYDRUS-1D soil temperatures which was small at soil depths (0–10) cm, but it was larger at soil depths (10–15) and (15–20) cm. The reason of that may be related to the sinusoidal equation which used by HYDRUS-1D; this commonly used for simulation soil temperature in the surface layer. theoretical equation in real conditions has noticeable deviations. But the profile distributions of soil temperatures (Figure 3) shows that the distributions of really measured soil temperature in the field conditions did not differ from its calculated soil temperature by program HYDRUS-1D. The range of temperature values and their profile distributions are close and adequate in dynamics.

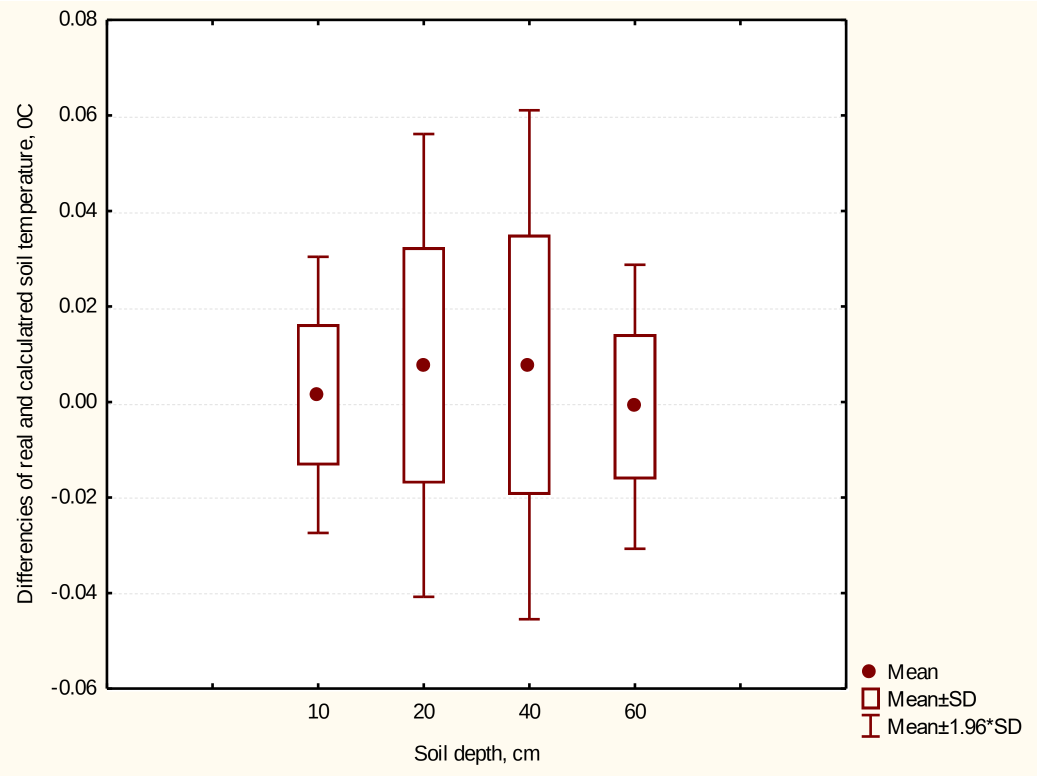
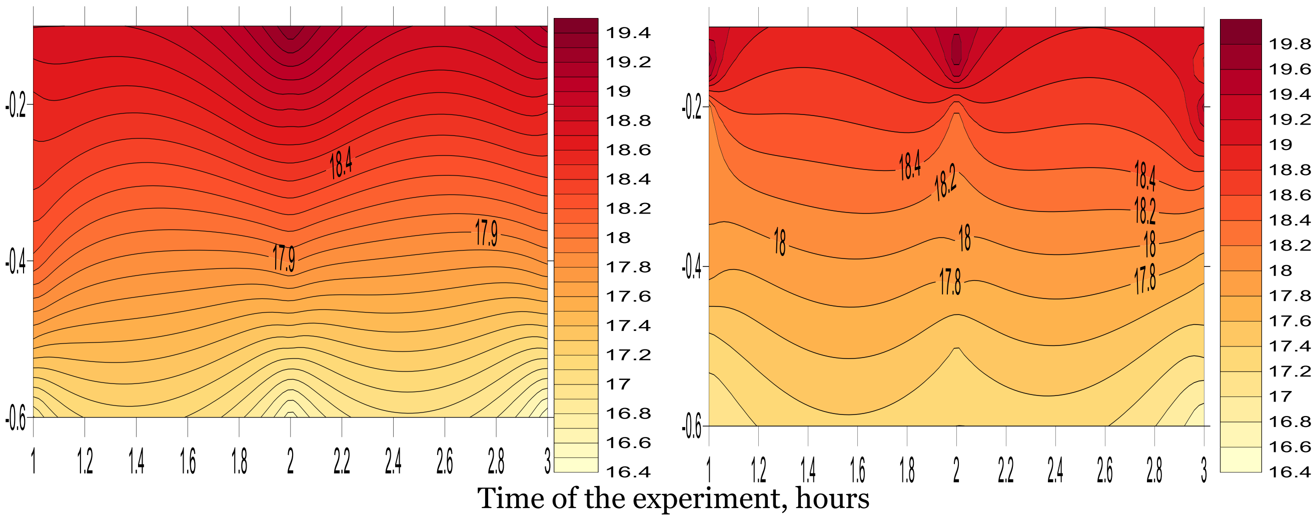



**Fig. 2**. Statistics of the differences between measured and calculated soil temperature using HYDRUS-1D for different depths of Albic Glossic Retisols




a) b)

**Fig. 3.** Soil temperature dynamics (a) in the field experiment and (b) calculated using the HYDRUS -1D program

## 4. Conclusion

HYDRUS-1D program is commonly used to estimate soil moisture and temperature dynamics. The efficiency of HYDRUS-1D increases at surface soil depths (0–15) cm. The efficiency of HYDRUS-1D depended on used initial and boundary conditions and the use of the hysteresis effect in case of irrigation of the dried soil. The difference between the field experimental data based on the dynamics of measured soil moisture and temperature in the field and its calculated soil moisture and temperature by HYDRUS-1D were small, which indicates to the possibility usage

HYDRUS-1D program for simulation of soil moisture and temperature dynamics (with hysteresis) for Albic Glossic Retisols.

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**References**

Chung, Horton, 1987 – *Chung S.O., Horton R.* (1987). Soil heat and water flow with a partial surface mulch. *Water Resour. Res.,* 23(12): 217-2186.

Gerke, van Genuchten, 1993a – *Gerke H.H. and van Genuchten M.Th.* (1993a). A dual-porosity model for simulating the preferential movement of water and solutes in structured porous media. *Water Resour. Res*., 29: 305-319.

Gerke, van Genuchten, 1993b – *Gerke H.H., van Genuchten M.Th.* (1993b). Evaluation of a first-order water transfer term for variably saturated dual-porosity flow models. *Water Resour Res*., 29: 1225-1238.

Jarvis et al., 2013 – *Jarvis N., Koestel J., Messing I., Moeys J. and Lindahl A.* (2013). Influence of soil, land use and climatic factors on the hydraulic conductivity of soil. *Hydrol Earth Syst. Sci*., 17: 5185-5195. DOI: https://doi.org/10.5194/hess-17-5185–2013

Jorda et al., 2015 – *Jorda H., Bechtold M., Jarvis N. and Koestel J.* (2015). Using boosted regression trees to explore key factors controlling saturated and near-saturated hydraulic conductivity. *European Journal of Soil Science*, 66(4): 744-756. DOI: https://doi.org/10.1111/ejss.12249

Kool, Parker, 1987 – *Kool J.B.,Parker J.C.* (1987). Development and evaluation of closed-form expressions for hysteretic soil hydraulic properties. *Water Resour. Res*., 23(1): 105-114.

Mady, Shein, 2018 – *Mady A.Y., Shein E.V.* (2018). Modelling and validation hysteresis in soil water retention curve using tomography of pore structure. *Int. J.* Water,12(4): 370-381. DOI: 10.1504/IJW.2018.10016241

Shein, Mady, 2016 – *Shein E.V., Mady A.Y.* (2016). Soil Thermal Parameters Assessment by Direct Method and Mathematical Models. *Journal of Soil Science and Environmental Management,* 7(10): 166-172. DOI: 10.5897/JSSEM2016.0585

Shein and Mady, 2018 – *Shein E.V., Mady A.Y.* (2018). Hysteresis of the water retention curve: wetting branch simulation based on the drying curve. *Moscow University Soil Science Bulletin*, 73(3): 124-128. DOI: 10.3103/S0147687418030080

Shein et al., 2015 – *Shein E.V., Mady A.Y., El Hassna A. Mohamed*. (2015). Soil Saturated Hydraulic Conductivity Assessment by Direct and Pedotransfer Functions Methods. *Biogeosystem Technique*, 6(4): 396-400. DOI: 10.13187/bgt.2015.6.396

Simunek et al., 2001 – *Simunek J., Wendroth O., Wypler N., van Genuchten M.Th.* (2001). Non-equilibrium water flow characterized by means of upward infiltration experiments. *Europ. J. Soil Sci*., 52: 13-24.

Simunek et al., 2003 – *Simunek J., Jarvis N.J., van Genuchten M.T., Gardenas A.* (2003). Nonequilibrium and preferential flow and transport in the vadose zone: review and case study. *J. Hydrology,* 272: 14-35.

Simunek et al., 2008 – *Simunek J. van Genuchten M.Th., Sejna M*. (2008). Development and Applications of the HYDRUS and STANMOD Software Packages and Related Codes. *Vadose Zone J.,* 7(2): 587.

Van Genuchten, 1980 – *Van Genuchten M.Th.* (1980). A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. *Soil Sci. Soc. Am. J.,* 44(5): 892-898.