**SUPPLEMENTARY MATERIALS – ДОПОЛНИТЕЛЬНЫЕ МАТЕРИАЛЫ**

**Transformation of surface layer pf ploughed soil horizon under the impact of atmospheric precipitation**

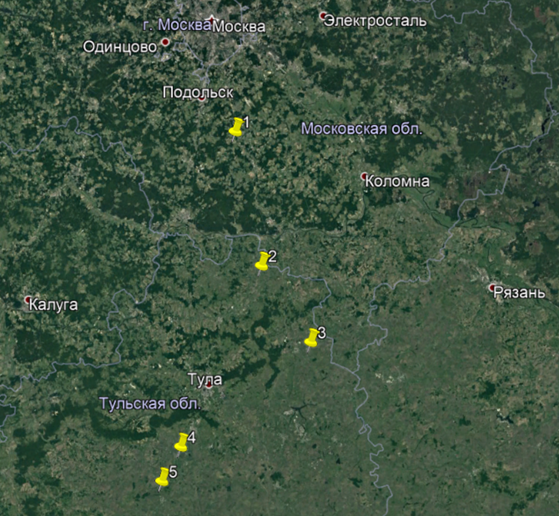
**Трансформация поверхностного слоя пахотного горизонта почв под влиянием атмосферных условий**

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**Eurasian Soil Science.**

**Почвоведение.**



**Fig. S1.** Test plots for the collection of soil samples and field survey: 1 - Domodedovo region of Moscow oblast; 2 - Yasnogorsk region of Tula oblast; 3 - Venev region of Tula oblast; 4 - Schekino region of Tula oblast; 5 - Plavsk region of Tula oblast.

**Рис. S1.** Тестовые участки для отбора образцов почв и полевых наблюдений: 1 - Домодедовский район Московской области; 2 - Ясногорский район Тульской области; 3 - Веневский район Тульской области; 4 - Щекинский район Тульской области; 5 - Плавский район Тульской области



**Fig. S2.** Water-resistant humus aggregates on the surface of chernozem soils in the field

**Рис. S2.** Водоустойчивые гумусированные агрегаты на поверхности черноземных почв в поле



а б в



г д е

**Fig. S3.** Transformation of soil surface under the impact of atmospheric conditions in model experiment (sod-podzolic soils (а, г), gray forest soils (б, д), leached chernozem (в, е); soil surface before transformation – а, б, в; after transformation – г, д, е).

**Рис. S3.** Трансформация поверхности почв под воздействием атмосферных условий в модельном эксперименте: дерново-подзолистая почва (а, г), серая лесная почва (б, д), чернозем выщелоченный (в, е); нетрансформированная поверхность – а, б, в; трансформированная – г, д, е.



а б в

**Fig. S4.** Models of micromonoliths of upper 4-cm of soil surface layer (a – leached chernozem, б – grey forest soil, в – sod-podzolic soil).

**Рис. S4.** Модели микромонолитов поверхностного 4-сантиметрового слоя почв (а – чернозем выщелоченный, б – серая лесная почва, в – дерново-подзолистая почва).

**Table S1.** Chemical properties, content of macro- and microelements of ploughed horizon of grey forest soils (24 samples).

**Таблица S1.** Химические свойства, содержание макро- и микроэлементов в пахотном горизонте серых лесных пахотных почв (24 образца).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Mixed sample of ploughed horizon (0-20 sm) | | | | | | Crust layer (0-2 mm) | | | | | |
| min | max | mean | median | standard deviation | coefficient of variation (%) | min | max | mean | median | standard deviation | coefficient of variation (%) |
| Chemical properties | | | | | | | | | | | | |
| pHw | 5.8 | 7.5 | 6.5 | 6.3 | 0.6 | 9.3 | 5.8 | 7.5 | 6.3 | 6.2 | 0.6 | 9.1 |
| pHs | 4.9 | 6.7 | 5.5 | 5.1 | 0.7 | 13.4 | 4.8 | 6.7 | 5.4 | 5.1 | 0.7 | 12.9 |
| Caex, cmolc/kg | 16.3 | 86.6 | 38.2 | 32.5 | 22.2 | 58.0 | 25.2 | 116.6 | 42.3 | 27.7 | 28.6 | 67.7 |
| Mgex, cmolc/kg | 1.4 | 2.3 | 1.9 | 1.9 | 0.3 | 16.9 | 1.7 | 3.0 | 2.2 | 2.1 | 0.4 | 19.1 |
| Kex, cmolc/kg | 0.3 | 0.9 | 0.5 | 0.4 | 0.2 | 34.9 | 0.3 | 0.7 | 0.4 | 0.4 | 0.1 | 32.2 |
| Naex, cmolc/kg | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 26.0 | 0.0 | 0.2 | 0.1 | 0.1 | 0.1 | 58.9 |
| P2O5av (mg/100 g) | 11.1 | 304.9 | 77.6 | 13.4 | 107.6 | 138.7 | 8.9 | 367.8 | 74.7 | 12.2 | 122.0 | 163.3 |
| K2Oav (mg/100 g) | 16.2 | 38.8 | 22.9 | 19.0 | 7.8 | 34.1 | 14.3 | 30.4 | 19.3 | 16.4 | 6.0 | 30.8 |
| Na2Oav (mg/100 g) | 0.3 | 0.7 | 0.4 | 0.4 | 0.2 | 35.1 | 0.1 | 1.2 | 0.7 | 0.7 | 0.4 | 58.1 |
| Content of macroelements (%) | | | | | | | | | | | | |
| Al2O3 | 11.0 | 12.2 | 11.6 | 11.6 | 0.4 | 3.7 | 10.7 | 12.8 | 12.0 | 12.1 | 0.7 | 5.8 |
| SiO2 | 69.9 | 73.2 | 71.6 | 71.7 | 1.3 | 1.8 | 68.1 | 72.7 | 71.0 | 70.9 | 1.4 | 2.0 |
| P2O5 | 0.1 | 0.6 | 0.2 | 0.2 | 0.2 | 68.3 | 0.1 | 0.5 | 0.2 | 0.1 | 0.1 | 66.0 |
| SO3 | 0.2 | 0.4 | 0.3 | 0.2 | 0.1 | 22.9 | 0.2 | 0.3 | 0.3 | 0.3 | 0.0 | 16.7 |
| Cl | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 26.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30.5 |
| K2O | 2.1 | 2.3 | 2.2 | 2.2 | 0.1 | 2.8 | 2.1 | 2.3 | 2.2 | 2.2 | 0.1 | 2.4 |
| CaO | 0.9 | 2.2 | 1.2 | 0.9 | 0.5 | 41.1 | 0.9 | 2.5 | 1.2 | 1.0 | 0.5 | 43.1 |
| TiO2 | 0.7 | 0.9 | 0.8 | 0.9 | 0.1 | 8.4 | 0.7 | 0.9 | 0.8 | 0.9 | 0.0 | 5.6 |
| Cr2O3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 13.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.2 |
| MnO | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 12.4 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 16.9 |
| Fe2O3 | 3.6 | 4.1 | 3.8 | 3.7 | 0.2 | 4.6 | 3.6 | 4.2 | 3.9 | 3.9 | 0.2 | 5.1 |
| Content of microelements (µg/g) | | | | | | | | | | | | |
| Ni | 24.0 | 36.0 | 30.5 | 32.0 | 4.4 | 14.3 | 23.0 | 41.0 | 32.3 | 32.0 | 5.8 | 17.9 |
| Cu | 18.0 | 33.0 | 24.5 | 23.5 | 5.2 | 21.0 | 22.0 | 31.0 | 26.8 | 27.0 | 3.3 | 12.4 |
| Zn | 56.0 | 94.0 | 67.1 | 62.0 | 13.2 | 19.7 | 55.0 | 92.0 | 66.3 | 62.5 | 10.9 | 16.4 |
| Ga | 17.0 | 25.0 | 20.6 | 20.0 | 3.2 | 15.3 | 16.0 | 23.0 | 20.9 | 21.5 | 2.5 | 11.8 |
| As | 7.0 | 11.0 | 8.1 | 8.0 | 1.4 | 16.7 | 4.0 | 14.0 | 8.0 | 7.0 | 3.5 | 44.1 |
| Br | 16.0 | 21.0 | 18.0 | 17.5 | 2.1 | 11.9 | 6.0 | 19.0 | 12.1 | 12.5 | 4.6 | 38.1 |
| Pb | 92.0 | 99.0 | 95.0 | 95.5 | 2.5 | 2.6 | 13.0 | 97.0 | 55.1 | 54.5 | 42.3 | 76.8 |
| Rb | 124.0 | 141.0 | 129.3 | 126.5 | 6.5 | 5.0 | 95.0 | 145.0 | 114.0 | 111.0 | 19.7 | 17.3 |
| Sr | 37.0 | 41.0 | 38.9 | 38.5 | 1.6 | 4.2 | 35.0 | 131.0 | 82.2 | 81.5 | 46.6 | 56.7 |
| Y | 466.0 | 531.0 | 511.8 | 516.5 | 21.0 | 4.1 | 39.0 | 528.0 | 271.6 | 259.5 | 243.9 | 89.8 |
| Zr | 15.0 | 20.0 | 17.9 | 19.0 | 2.0 | 11.0 | 16.0 | 544.0 | 267.3 | 257.5 | 263.5 | 98.6 |
| Nb | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | - | 0.0 | 21.0 | 9.6 | 8.5 | 10.2 | 106.0 |

pHw – рН водной вытяжки (pH of water extract), pHs – рН солевой вытяжки (pH of KCl extract), Caex, Mgex, Kex, Naex – обменные катионы кальция, магния, калия и натрия по Шолленбергеру (exchangeable cations of calcium, magnesium, potassium and sodium by Shollenberger); P2O5av – подвижные соединения фосфора по методу Кирсанова (mobile phosphorus by Kirsanov method), K2Oav – обменный калий по методу Масловой (exchangeable potassium by Maslova method), Na2Oav – обменный натрий (exchangeable sodium).

**Table S2.** Chemical properties, content of macro- and microelements of ploughed horizon of leached chernozems (14 samples).

**Таблица S2.** Химические свойства, содержание макро- и микроэлементов в пахотном горизонте черноземов оподзоленных (14 образцов).

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Parameter | Mixed sample of ploughed horizon (0-20 sm) | | | | | | Crust layer (0-2 mm) | | | | | |
| min | max | mean | median | standard deviation | coefficient of variation (%) | min | max | mean | median | standard deviation | coefficient of variation (%) |
| Chemical properties | | | | | | | | | | | | |
| pHw | 5.8 | 6.2 | 5.9 | 5.9 | 0.2 | 2.9 | 5.8 | 6.1 | 5.9 | 5.9 | 0.1 | 2.1 |
| pHs | 4.6 | 5.0 | 4.8 | 4.9 | 0.2 | 3.5 | 4.7 | 5.0 | 4.8 | 4.8 | 0.1 | 2.5 |
| Caex, cmolc/kg | 31.4 | 41.2 | 36.5 | 36.8 | 5.0 | 13.6 | 13.6 | 55.6 | 34.2 | 33.8 | 18.4 | 53.6 |
| Mgex, cmolc/kg | 2.2 | 2.6 | 2.4 | 2.5 | 0.2 | 8.5 | 1.9 | 3.1 | 2.4 | 2.3 | 0.6 | 22.9 |
| Kex, cmolc/kg | 0.4 | 0.7 | 0.5 | 0.6 | 0.1 | 19.8 | 0.5 | 0.6 | 0.5 | 0.5 | 0.0 | 9.1 |
| Naex, cmolc/kg | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 19.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 12.3 |
| P2O5av (mg/100 g) | 11.4 | 15.6 | 13.3 | 13.1 | 1.8 | 13.5 | 12.5 | 13.4 | 12.9 | 12.8 | 0.4 | 3.3 |
| K2Oav (mg/100 g) | 18.7 | 29.0 | 24.2 | 24.4 | 4.8 | 19.7 | 22.3 | 26.6 | 24.0 | 23.6 | 1.9 | 7.8 |
| Na2Oav (mg/100 g) | 0.0 | 1.4 | 0.4 | 0.2 | 0.6 | 150.0 | 0.0 | 2.8 | 0.7 | 0.1 | 1.4 | 187.1 |
| Content of macroelements (%) | | | | | | | | | | | | |
| Al2O3 | 11.5 | 12.5 | 12.2 | 12.3 | 0.4 | 3.7 | 11.9 | 13.5 | 12.5 | 12.3 | 0.7 | 5.5 |
| SiO2 | 66.6 | 68.4 | 67.8 | 68.1 | 0.8 | 1.2 | 68.2 | 72.8 | 69.4 | 68.4 | 2.2 | 3.2 |
| P2O5 | 0.2 | 0.2 | 0.2 | 0.2 | 0.0 | 10.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.0 | 12.6 |
| SO3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 | 8.3 | 0.2 | 0.4 | 0.3 | 0.3 | 0.1 | 26.2 |
| Cl | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 25.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30.5 |
| K2O | 2.0 | 2.2 | 2.1 | 2.1 | 0.1 | 3.7 | 2.0 | 2.4 | 2.2 | 2.2 | 0.1 | 6.8 |
| CaO | 1.1 | 1.2 | 1.2 | 1.2 | 0.1 | 4.8 | 1.1 | 1.5 | 1.2 | 1.2 | 0.2 | 13.4 |
| TiO2 | 0.8 | 0.8 | 0.8 | 0.8 | 0.0 | 1.0 | 0.8 | 0.9 | 0.8 | 0.8 | 0.0 | 3.6 |
| Cr2O3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 22.7 |
| MnO | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 5.8 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 6.5 |
| Fe2O3 | 4.2 | 4.3 | 4.2 | 4.3 | 0.1 | 1.4 | 4.1 | 4.4 | 4.2 | 4.3 | 0.1 | 2.7 |
| Content of microelements (µg/g) | | | | | | | | | | | | |
| Ni | 27.0 | 38.0 | 32.8 | 33.0 | 4.8 | 14.6 | 31.0 | 38.0 | 34.0 | 33.5 | 3.2 | 9.3 |
| Cu | 19.0 | 24.0 | 21.5 | 21.5 | 2.4 | 11.1 | 22.0 | 27.0 | 24.3 | 24.0 | 2.2 | 9.1 |
| Zn | 53.0 | 58.0 | 56.0 | 56.5 | 2.4 | 4.4 | 54.0 | 59.0 | 56.8 | 57.0 | 2.1 | 3.6 |
| Ga | 19.0 | 26.0 | 22.8 | 23.0 | 3.0 | 13.1 | 19.0 | 25.0 | 21.5 | 21.0 | 2.6 | 12.3 |
| As | 5.0 | 16.0 | 10.3 | 10.0 | 5.1 | 50.0 | 5.0 | 13.0 | 8.8 | 8.5 | 3.9 | 44.1 |
| Br | 10.0 | 19.0 | 14.3 | 14.0 | 3.8 | 26.5 | 11.0 | 15.0 | 14.0 | 15.0 | 2.0 | 14.3 |
| Pb | 13.0 | 99.0 | 56.3 | 56.5 | 47.7 | 84.8 | 14.0 | 97.0 | 56.0 | 56.5 | 46.8 | 83.5 |
| Rb | 94.0 | 134.0 | 113.0 | 112.0 | 21.5 | 19.0 | 95.0 | 135.0 | 115.0 | 115.0 | 21.4 | 18.6 |
| Sr | 37.0 | 137.0 | 86.8 | 86.5 | 56.3 | 64.9 | 37.0 | 134.0 | 84.5 | 83.5 | 54.3 | 64.3 |
| Y | 38.0 | 475.0 | 247.8 | 239.0 | 242.1 | 97.7 | 37.0 | 482.0 | 259.5 | 259.5 | 256.3 | 98.8 |
| Zr | 18.0 | 505.0 | 255.8 | 250.0 | 274.7 | 107.4 | 18.0 | 501.0 | 249.3 | 239.0 | 267.0 | 107.1 |
| Nb | 16.0 | 17.0 | 16.5 | 16.5 | 0.7 | 4.3 | 17.0 | 18.0 | 17.5 | 17.5 | 0.7 | 4.0 |

pHw – рН водной вытяжки (pH of water extract), pHs – рН солевой вытяжки (pH of KCl extract), Caex, Mgex, Kex, Naex – обменные катионы кальция, магния, калия и натрия по Шолленбергеру (exchangeable cations of calcium, magnesium, potassium and sodium by Shollenberger); P2O5av – подвижные соединения фосфора по методу Кирсанова (mobile phosphorus by Kirsanov method), K2Oav – обменный калий по методу Масловой (exchangeable potassium by Maslova method), Na2Oav – обменный натрий (exchangeable sodium).