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UKRAINIAN AND CHINESE MOLLISOLS: DISTRIBUTION, FORMATION AND PROPERTIES

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The article summarizes research findings in soil survey, soil genesis and classification of Ukrainian and Chinese Mollisols. Mollisols have overviewed including their distributions, soil forming factors, features and morphology, as well as properties.

Mollisols, Map, Distribution, Classification, Properties, Soil Organic Matter, Bulk density, pH

Soils are the foundation of civilizations and the food production base for human life. However, all soils are not created equal. Mollisols are recognized as the world's leading grain and seed crop producing soils, and are found dominantly in only four different regions of the world. Both Ukraine and China have that most fertile resource, but it's prone to soil erosion by water and wind, degumification and suffer from antropogenic agents. The long run management of Mollisols caused changes in their properties and sustainable development (genesis). This paper reviews some issues of the Mollisols in Ukraine and Northeast China. The discussion herein rests primarily on literature from the two Mollisols regions.

Methods. Mollisols are known in other soil classification systems as Chernozems (Russia, FAO), Kastanozems and Phaeozems (FAO) and Isohumosols or Black soils (China). In the National Soil Classification System of Uruguay, they are included in the Great Groups of Brunosols and Argisols [1]. The name of Mollisols is officially used in the soil classification of Argentina. So called ′Black soil′ in Ukraine can be better described by Chernozems according to World Reference Base (IUSS, ISRIC, FAO), while black soil in China would better fit the Phaeozems by the FAO classification [2]. Chinese black soils belong to the pachic Haploborolls subtype of Haploborolls type in Borolls suborders, and the widespread Ukrainian black soils belong to the Cryoborolls, Argiborolls, and Haploborolls types in the Borolls suborder. For the purposes of unifying various approaches in soil classifications Ukrainian podzolized Chernozems are given herein as Wet Forest–Steppe Mollisols (WFSM), typical Chernozems – Forest–Steppe Mollisols (FSM), ordinary Chernozems – Steppe Mollisols (SM), southern Chernozems – South Steppe Mollisols (SSM).

Mollisols Distribution. Both Ukrainian and Chinese Mollisols are widely distributed in Forest–Steppe and Steppe areas, and extended into south semi–arid grasslands. Black soils in Ukraine (fig.1) are delineated within 51°18' – 44°41'N (737.18 km) and 24°18' – 40°12'E (1144.19 km). The region of Mollisols in China is

situated within 115°31' – 135°05'N (1400 km) and 38°43' – 53°33'E (1600 km). Ukrainian Mollisols capture 2.7x105 km^2 or 11.9% from World Mollisols – 2.3 x 106 km^2 [3], while Chinese Mollisols occupy 1.24x106 km^2 or 13.7% from World Mollisols – 9.0 x106 km^2 [4]. Over one–half of these occur in Heilongjiang Province (i.e., 54.5% of the China's total area of Mollisols) (fig.2).

Mollisols Forming Factors. Ukrainian Mollisols are formed in the temperate zone with short freezing period, and Chinese Mollisols are in the temperate zone with longer freezing period. The climate in Northeast China is continental with a long, dry, and severe cold winter and little snow, while that of Ukraine is warmer and milder in winter (table 1).

In general, the climate of Northeast China is humid in the east, semi-humid in the middle, and semi-arid in the west, while that of Ukraine is humid in the northwest, semi-humid in the middle and semi-arid in the southern region. Vegetation types in Northeast China include temperate evergreen conifer-deciduous broadleaf mixed forests, deciduous broadleaf forests, coniferous forests, and shrublands in the east, typical steppes and desert steppes in the west, and temperate savannas and meadow steppes in the middle (Jian and Zhang, 2000). The vegetation types found on Ukrainian Mollisols are oak-maple-lime-hornbeam forests with grasslands and meadows in the north, and meadow, fescue, and needle grasses with greater xerophytic and halophytic species towards the south.

1. Climatic parameters of Mollisols areas in Ukraine and China

Climatic parameter	Ukraine		China	
	Ternopol	Kherson	Hailun	Changtu
Solar radiation (kcal/(cm^2·yr))	102	122	118	135
Mean January temperature (°C)	–5.8	-3.0	-20.8	-10.5
Mean July temperature (°C)	17.4	21.9	20.0	25.0
Average annual temperature (°C)	6.7	9.8	2.8	6.8
Maximum depth of frost penetration (cm)	56	30	195	126
Number of days of temperature > 0°C (d)	255	312	216	230
Number of days of temperature > 5°C (d)	209	238	185	216
≥ 10°C accumulated temperature (°C)	2550	3700	2302	3256
Average annual precipitation (mm)	617	441	534	729
Relative humidity (%)	80	74	66	75

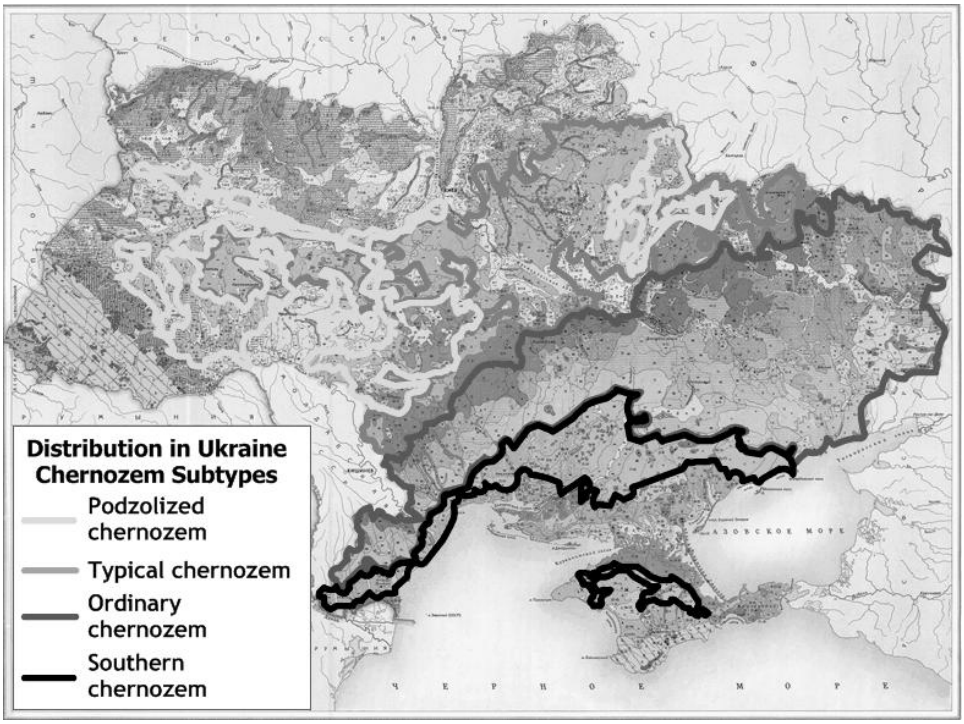


Figure 1. Mollisols Subtypes Distribution in Ukraine

Parent materials in both Ukrainian and Chinese Mollisols zones are characterized by 'lithologic uniformity' represented by the loess and loess-like loams. Typical Mollisols are located mainly within the Northeast China Plain and extended along the Songhua River.

About 29% of the area is occupied by the Northeast China Plain, with elevations up to 200 m. Typical Mollisols are located mainly within the Northeast China Plain and extended along Songhua River towards to Sanjiang Plain. Other subtypes of Mollisols capture different plains, uplands and pre-mountain areas of the Northeast China. Chestnut soils cover a big area of the Inner Mongolia Plateau and spread up to the Loess Plateau. Other subtypes of Mollisols cover different plains, uplands and pre-mountain areas of Northeast China. A small area of Mollisols can also be found in Central and Northwest China.

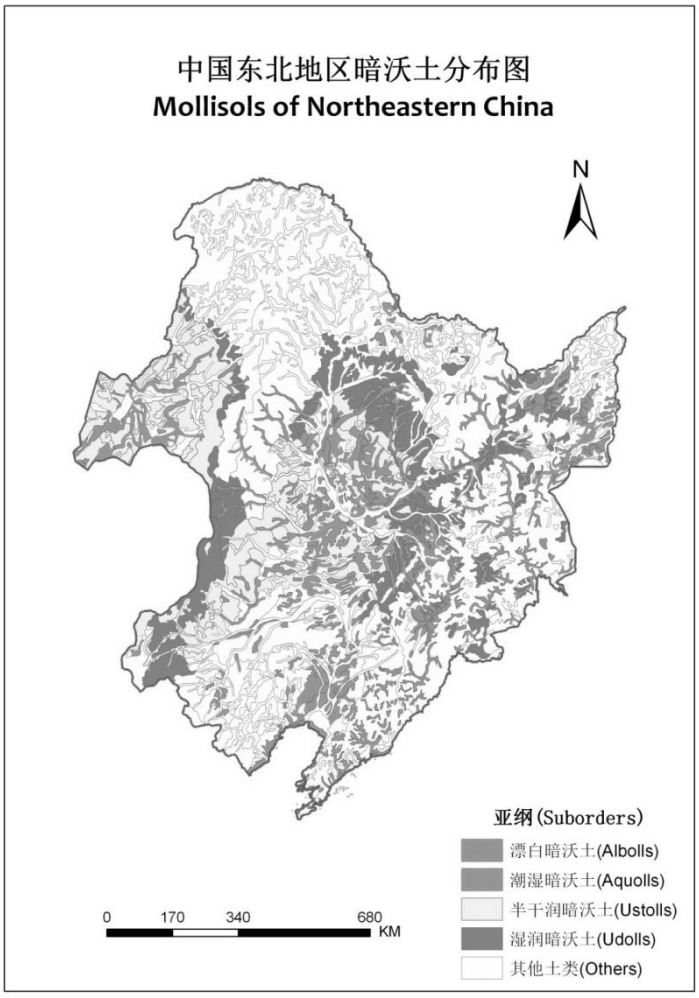
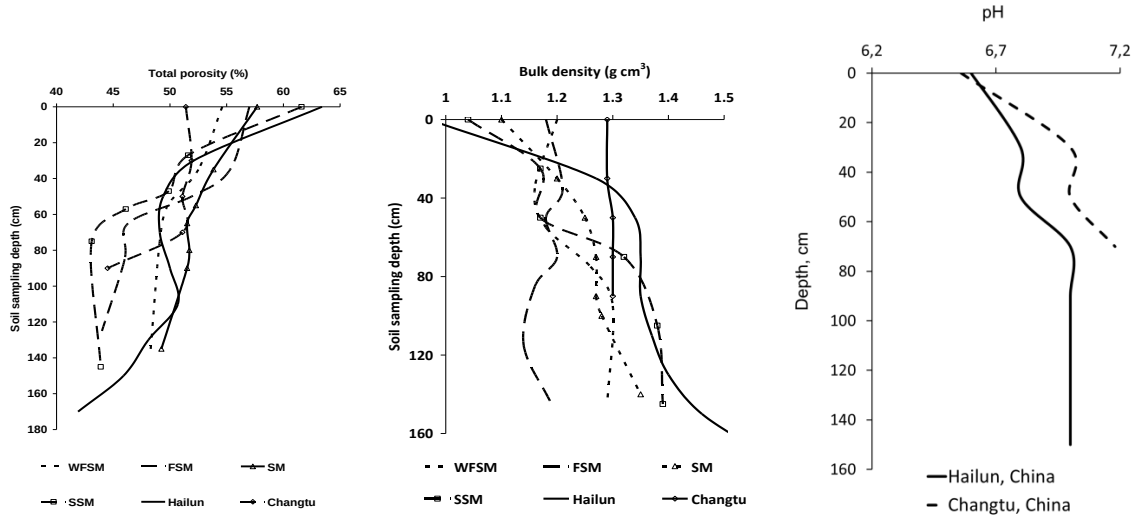


Figure 2. Mollisols Distribution in Northeast China

Topography in the area of spreading Ukrainian Mollisols is dominantly plainland but nonuniform in both genetic and structural respects. The Near-Black-Sea Lowland in the south gradually turns into a number of uplands (150-360 m above sea level). Toward the north, Pridniprovska, Donetsky lowland and Poltavska plainland spread on the left bank of Dnipro river. The north borderline of Mollisols verge on Polisska lowland.

Mollisols Classification. Mollisols (from Latin mollic, “soft”) are characterized by having well-developed structure (usually a granular or fine subangular blocky structure), deep, dark- colored surface horizon (larger than 18-25 cm), at least 1% SOM (0.6% organic carbon) on a weight basis, moist color with both chroma and value both being 3 or less for a moist sample and 5 or less for a dry sample, a minimum of 50% base saturation (by 1 M NH_4OAc) or more on a weighted average throughout the depth of the horizon, a thickness of the following horizon 10-25 cm or more and the lower boundary of the lowest diagnostic horizon within 75 cm [5,6,7].



a **b** **c**

Figure 2. Bulk density, g cm^{-3} (a), total porosity, % of soil volume (b) and pH (c) in Ukrainian and Chinese Mollisols

Mollisols properties. Black soils are reputed as the most famous soils in fertility and potential for producing higher crop yields. In spite of common black soil features, they vary in their properties. ***Soil texture.*** Soil texture in Mollisol changes from light loam to middle clay. Coarse silt and clay are dominant among all soil particles in Mollisols, but their distribution is different. Ukrainian Mollisols become heavier from the north to the south, while in Chinese ones alter quite the opposite. The content of physical clay (∑<0.01%) vary within 25-65% from WFSM till SSM in Ukraine and 47-49% in Changtu Mollisols, China. Chinese Mollisols from Liaoning Province have similar with FSM and SM content of coarse silt and physical clay. The amount of clay particles (∑<0.02%) increases from 47.26 to 70.09% in Chinese Mollisols upstream from Changtu and Hailun, respectively. ***Soil organic matter***. Soil organic matter (SOM) content in Ukrainian Mollisols increases from WFSM to FSM and SM, but in SSM its content decreases again: 5.19%; 5.7%; 6.2%; 3.4% [8]. The type of humus (a ratio of the carbon content in humic to fulvic acids, Cha/Cfa) changes respectively from 1.13 to 1.53; 2.5; 2.9 or from fulvate-humatic to humatic and fulvate-humatic type again. The distribution of humus horizons (H+Hp+Ph) through the soil profile is extended from WFSM (100-120 cm) to FSM (160-200 cm) and reduced to SM (120-160 cm) with SSM (70-110 cm) [9]. The content of SOM in Chinese black soils have a tendency became less - from Heilongjiang to Liaoning province. ***The bulk density.*** The bulk density in Mollisols depends on humus content and soil texture and is found in favorable for plants ranges: 0.9-1.3 g cm^{-3} in Ukrainian Mollisols [10] and 0.97-1.29 g cm^{-3} in Chinese ones (fig. 2 a). Bulk density is an indirect measure of soil pore space. Mollisols have about 50-60% porosity by volume (fig. 2 b). Changtu Mollisols (China), in spite of the highest value of bulk density and lowest index of total porosity, possess with sufficient conditions for growing most of the crops. ***pH***. Mollisols, as a rule, have a neutral reaction, with soil pH ranged from 6.6 to 8.6 in Ukrainian and China (fig. 2 c). They hold pH 7.0-7.4 in the upper subsurfaces, but towards to the south the pH

in the loesses increased up to 7.6-8.1 in China (Changtu, China) and 8-8.6 in Ukraine (South Steppe Mollisols).

Conclusion. Mollisols distribution strongly correlates with: subboreal geographic belt, humid, semi-humid, and semi-arid zones, Forest-Steppe and Steppe ecosystems, loess sediments but it is not limited to them. Their predominant use is cereal production in Ukraine and soybean, corn, rice farming in China. Mollisols in Ukrainian soil classification take up a position of soil type, while in Chinese – group name. Ukrainian and Chinese Black soils keep together 16.8% of World Mollisols and play the global role in the food security of both countries and European-Asian continents in whole.

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У статті наведено узагальнені результати наукових досліджень із географії, генезису та класифікації українських і китайських чорноземів. Висвітлені питання поширення, ґрунтоутворюючих факторів, морфологічних ознак та властивостей Молісолів.

Молісолі, карта, поширення, класифікація, властивості, органічна речовина ґрунту, щільність зложення, pH.

В статье приведены обобщенные результаты научных исследований по географии, генезису и классификации украинских и китайских черноземов. Освещены вопросы распространения, почвообразующих факторов, морфологических признаков и свойств Молисолей.

Молисоли, карта, распространение, классификация, свойства, органическое вещество почвы, плотность сложения, pH.