History of the soil, cultural layer, and people in medieval Moscow

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ABSTRACT

The specificity of urban soils, especially those in the central part of Moscow, consists of continuous accumulation of a thick layer of habitation deposits (the cultural layer); its main thickness varies from 3 to 5 m. These deposits have accumulated since the 12th century and are characterized by a high content of organic matter, carbonates, phosphorus compounds, and various microelements. Strong alkalinity and high stone content are also characteristic of this layer. Our study revealed the indices of accumulation of a number of elements and their compounds within the habitation deposits of Moscow. The composition of microelements in the bone tissue of people buried at that time show additional information about their living conditions.

Key words: Cultural layer, soil, anthropogenic, geochemistry, bone, paleoecology

RESUMEN

La especificidad de los suelos urbanos, especialmente aquéllos localizados en la parte central de Moscú, consiste en una acumulación continua de estratos gruesos de depósitos habitacionales (estrato cultural); su espesor principal varía de 3 a 5 metros. Estos depósitos se han acumulado desde el Siglo XII y se caracterizan por un alto contenido de materia orgánica, carbonatos, compuestos de fósforo y varios microelementos. Una fuerte alcalinidad y un alto contenido de piedras son también características de este estrato. Nuestro estudio reveló los índices de acumulación de ciertos elementos y sus compuestos, dentro de los depósitos habitacionales de Moscú. La composición de microelementos en el tejido óseo de la población enterrada en ese tiempo, ofrece información adicional sobre sus condiciones de vida.

Palabras clave: Estrato cultural, suelo, antropogénico, geoquímica, hueso, paleoecología.

INTRODUCTION

The soils of Moscow have a long history of development and represent a complex and rapidly changing environment of natural and anthropogenic formation. Initially, the soil cover of Moscow was composed of Podzoluvisols that formed during the Holocene in lithologically diverse sediments. These soils are still preserved in Moscow within forest groves and park zones; in the rest of the territory they are strongly transformed. The main differences between urban soils and natural soils are related to active accumulation of anthropogenic wastes that form a cultural layer (habitation deposits) with specific properties and composition (Blume, 1989; Stroganova and Agarkova, 1992; Burghart, 1994; Dobrovol'skiy, 1997).

Several types of habitation deposits can be distinguished: debris from house construction, municipal wastes, excavated bedrock (from digging of foundation pits), industrial wastes and pollutants, artificially introduced or created lawn and garden soils, and so forth. The cultural layer buries the initial soil and is characterised high alkalinity, stratification, evident traces of different technological impacts, and a high stone content. It also contains a wide range of chemical elements, including those considered pollutants (Thornton, 1991), and contains numerous archaeological artefacts (Boytsov *et al.,* 1993). Besides, there are various traces of soil formation within this layer, including poorly developed buried soils. Thus, this layer is simultaneously a soil, a sediment, and a cultural layer (Alexandrovskiy *et al.*, 1997). The soil processes in it are peculiar to urban soils (Dobrovol'skiy, 1997).

This study has multiple aims, including the reconstruction of 1) the initial natural environment and landscape of the territory of Moscow (10–11th centuries); 2) the rural landscape in the early stages of Moscow's history (12–14th century); 3) the historical landscape of the medieval town in the 15–17th centuries; and 4) to determine the living conditions of ancient peoples in these landscapes.

MATERIALS AND METHODS

The history of the interaction between the humans and the environment can be revealed and traced in urban soils by means of pedological and paleogeographical methods (Boytsov *et al.,* 1993). An archaeological–geological–pedological approach is suggested for the study of these unique objects. The use of the methods of geochemistry, especially for bone tissue of ancient peoples, can be also very fruitful for the reconstruction of living conditions.

The content of organic matter, carbonates, and phosphorus was determined in buried soils and the cultural layer of Moscow by routine methods. Analysis of the microelement composition of habitation deposits and bone tissue was carried out by the X–ray fluorescence method whereby the object under study is kept intact.

RESULTS

In the central part of Moscow, on interfluves and high river terraces, the thickness of the cultural layer overlying the buried pre-settlement soil reaches 2-3 m thickness. In depressions (flat-bottom ravines, river valleys, sinkholes) it is commonly 7-10 m, occasionally reaching 20 m thickness in some places. This layer has the following composition:

1) The buried pre-settlement (natural) soil at the base of the stratigraphic section is usually a Podzoluvisol, developed from different deposits of sandy–loamy texture. Often, the initial soil contains a plough horizon 7–12-cm thick (Alexandrovskiy and Krenke, 1993), sometimes with erosion features.

2) Above the surface of the buried natural soil we can often see a humus-rich horizon of more clayey texture with some inclusions of construction wastes. This horizon was formed during the period of wooden construction; it is referred to as an organic-rich cultural layer. Sometimes, this horizon includes the remains of decomposed wooden chips, rotten manure, and other plant remains.

3) A much thicker layer with increased stone content lies above the organic-rich cultural layer. It is enriched with brick debris and lime that was applied during the period of stone construction. This horizon is referred to as a lithogenic horizon and is marked by lower humus content and alkaline reaction.

Both within the cultural layer and at its surface we can distinguish a layer with poorly developed soils. Most of these soils are composed only of a humus horizon with a gradual transition to the underlying material.

The habitation deposits differ from the zonal Podzoluvisols of the Moscow region in that they contain more organic matter, carbonate, and phosphorus. The main sources of carbonate were the limestone and mortar that was widely used beginning in the 17–18th centuries. Carbonate has migrated into lower layers, including the initial Podzoluvisol, and the reaction of these layers has changed from acid to alkaline (Table 1). The phosphorus content of the cultural layer is many times that the Podzoluvisols of the surrounding area.

The 11–12th century layers under Red Square are marked by a relatively low content of metals and other elements. The habitation deposits of the 12–13th centuries under Red Square contain much organic matter, primarily woody remains. They are relatively enriched in carbonates owing to the input of lime derived from construction limestone. Cu and Zn content has also increased, because these elements were used for various purposes at that time, together with As, which was used for depilation during the tanning process (Guya, 1962; Alexandrovskaya, 1996). In the cultural layers of old towns of the Kursk region, accumulations of these elements are higher than in recent municipal deposits (Kaidanova, 1992).

In more recent deposits of Moscow, the content of

Table 1. Analytical data for the cultural layer, surface and buried soils from Moscow. CL1: brick-lime cultural layer; CL2: organic-rich cultural layer.

Age (century)	Layer or horizon	Depth (cm)	pH	Humus (%)	$CaCO_3$	$P_{extractable}$ (mg/100g)	Cu ($mg \cdot kg^{-1}$)	Pb ($mg \cdot kg^{-1}$)	As ($mg \cdot kg^{-1}$)
Site: Tverskoy boulevard, 16 (yard)									
20	A1	10	7.8	2.3	5.3	240	108	133	19
19	AB	40	7.4	4.9	3.2	212	105	264	31
19	CL1	60	7.7	2.4	5.3	1864	247	461	53
18	CL1	80	7.9	4.1	5.2	12	1014	890	58
17/18	A1	135	7.5	3.9	2.0	232	154	108	23
	CL1	175	7.5	4.6	4.5	360	198	226	30
17	CL2	175	7.5	3.1	1.2	384	137	123	17
	CL2	240	7.2	2.6	0.0	418	299	43	17
15/16	Ap	255	7.3	1.5	0.0	366	81	15	3
	A2B	270	7.3	0.2	0.0	110	14	7	4
Site: Romanov Lane, 4 (Moscow University Yard)									
20	A1	10		4.7		66.7	197	228	8
19/20	AB	75		3.2		132.9	125	51	12
19	CL1	110		5.0		131.6	183	161	25
	A1	170		3.2		240.4	90	24	17
18	CL1	230		1.2		232.8	1204	57	11
17	CL1	230		1.6		212.0	1910	120	25
17	CL1/2	290		5.5		226.5	-	-	-
17	CL1/2	315		2.2		301.7	30	20	6
16	CL12	325		8.7		411.8	-	-	-
16	Ap	345		3.1		276.2	72	17	8
15	E	360		0.4		165.8	9	8	8
Site: Natural soil near Moscow									
	A1	0-10	4.7	3.6	0.0	5.0	12	5	2

calcium oxide and many microelements increase considerably. In the Kremlin, (Table 2) medieval cultural deposits proved much cleaner than in the nearest town (Ilyinka site; Table 3).

Horizons of the 17–19th centuries contain the maximum concentration of such elements as lead, copper and arsenic. Thus, the concentration of arsenic increases up to 74 $mg \cdot kg^{-1}$ (as compared to the Clarke value of 2 $mg \cdot kg^{-1}$). The average concentration of Cu in natural soils of the Moscow region is 3-20 $mg \cdot kg^{-1}$, but in the cultural layer of the 15-16th centuries, it reaches 650 $mg \cdot kg^{-1}$. The Clarke value for Pb is 13 $mg \cdot kg^{-1}$ (3–5 $mg \cdot kg^{-1}$ in natural soils), but in the cultural deposits of the 19th century it can reach 1,320 $mg \cdot kg^{-1}$.

The next research stage was a study of the microelement composition of bone tissue recovered from burial grounds of the grand Russian princesses and czarinas of the 15th and 16th centuries in the cemetery of the Ascension Convent of the Kremlin (Table 4), as well as remains of the urban population of different social and age groups (Tables 5, 6).

In the bone tissue of highborn Russian ladies of the 15th, 16th, and early 17th centuries we see an enhanced concentration of lead, mercury, copper, occasionally barium and other elements that might have been present in the cosmetics used at the time (which often contained toxic agents) (Table 4). Sure enough, our contemporaries recoil at the mere mention of substances like white lead, antimony,

Table 2. Microelements in soils and deposits near the Archangel Cathedral in the Moscow Kremlin ($mg \cdot kg^{-1}$).

Dig, sample, century	Ni	Cu	Zn	Hg	As	Pb
Mean concentration in the earth crust	99	30	76	0.5	2	13
1st trench, north, 15th century deposits	8	34	49	1.6	5	14
1st trench, south, 15th century deposits, 120 cm deep	31	57	103	1.2	6	24
15th century deposits, 150 cm pit	24	59	99	0.9	5	28
14th century deposits, 200 cm pit	13	26	57	0.7	5	10

Table 3. Microelements in soils and deposits of Moscow (mg·kg^{-1}).

Dig, sample, century	Ni	Cu	Zn	As	Pb
Mean concentration in the earth crust	99	30	76	2	13
Troitsa church (suburb of medieval Moscow)					
16th century, deposits	9	31	42	8	13
15th century, deposits	11	13	42	7	7
14th - 15th century, deposits/buried soil	11	83	51	9	9
Initial soil	9	15	21	5	2
Ilyinka street (near Kremlin)					
15th – 16th century, deposits	44	205	486	16	94

Table 4. Microelements in bone tissue of women buried in the Kremlin (mg/100g of bone tissue).

Objects	Cu	Zn	Mn	Pb	As	Ag	Hg
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04	0.04
Evdociya Donskaya, 1407	1.1	10.0	10	20.0	0.1	0.04	0.03
Grand Princess Maria Borisovna, 1467	10.4	338	0.3	90.3	0.3	0.04	1.05
Grand Princess Sofia Paleolog, 1503	7.1	27.0	0.4	58.6	0.3	0.04	0.05
Grand Princess Yelena Glinskaya 1538	3.8	40.6	0.4	56.4	0.8	0.04	0.05
Czarina Anastasia Romanovna. 1560	9.1	24.9	0.3	160	0.8	6.6	0.13
Czarina Maria Nagaya, 1608	1.9	24.3	1.2	19.3	0.1	0.04	0.60

or cinnabar (the chief source of Hg), all of them highly poisonous. But fashionable ladies of the Middle Ages did use them. Drugs and salves were another source of poison. Some medicines contained Pb (Goulard water), and some salves contained Hg and As. Lead-containing remedies, by the way, appeared in Europe in the 10th century, and were in common use from the 15th century on. All the objects we have studied show enhanced concentrations of Hg. Large doses of this element are very harmful. The poisonous Hg could come from medical drugs, dyes (from cinnabar that was often used at the time), from vapors released in the process of gilding; the presence of an open Hg barometer in the Kremlin could likewise play a role.

In the bones of monks and townspeople of 14–16th centuries, the concentration of microelements is lower (Tables 5, 7, 8). Also in the remains of children from the Kremlin, the content of toxic elements was higher than in town children.

DISCUSSION

Several stages can be distinguished in the development of soils and the cultural layer of Moscow: 1) natural pedogenesis in a forested landscape; 2) anthropogenic transformation of the natural soils for arable and/or pastoral farming; 3) Burial of these soils under the cultural layer, their subsequent disturbance by digging, and their gradual transformation by diagenetic processes; 4) accumulation of the cultural layer with dispersed features of soil formation and development of distinct soil horizons.

Data obtained attest to active accumulation of As, Cu, Pb, etc. Copper appears in the habitation deposits from the 12–13th centuries, reaching a maximum in the 17–19th centuries. Increased concentrations of As are connected with the use of this element in the tanning and dyeing industries. Copper was used for domestic and horticultural pest control and as a ductile metal. Also, blue vitriol may have been

Table 5. Microelements in bone tissues of women buried in the Troitsa church (mg/100g of bone tissue).

Objects	Cu	Zn	Mn	Pb	As	Ag	Hg
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04	0.04
165 20-35 years old	0.9	48	112	1.0	0.1	0.01	0.03
209 25-35 years old	1.1	70	14.5	2.3	0.5	0.01	0.03
174 25- 35 years old	0.9	64	15.7	4.0	0.3	0.01	0.01
155 45-55 years old	0.3	36	70.0	10.5	0.1	0.01	0.03
198 45-55 years old	0.3	53	63.0	1.0	0.1	0.01	0.03

Table 6. Microelements in bone tissues of men buried in the Kremlin (mg/100g of bone tissue).

Objects	**Cu**	**Zn**	**Mn**	**Pb**	**As**	**Hg**
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04
Monk, grave 905	3.6	23.9	18	8.7	3.0	0.03
Monk, grave 906	3.9	39.8	14	32.0	5.6	0.09

Table 7. Microelements in bone tissues of men buried in the Troitsa church (mg/100g of bone tissue).

Object	**Cu**	**Zn**	**Mn**	**Pb**	**As**	**Ag**	**Hg**
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04	0.04
178 25-35 years old	0.3	60	8.4	0.3	0.1	0.01	0.01
228 25-35 years old	0.7	18	6.9	3.4	0.4	0.01	0.04
229 25-35 years old	0.7	29	12.7	1.6	0.2	0.01	0.03
162 35-45 years old	4.0	60	56.0	16.4	0.3	10.0	0.03
156 35-45 years old	0.9	60	27.8	5.9	0.1	0.01	0.03
164 35-45 years old	0.5	42	28.0	2.0	0.1	0.01	0.03
203 35-45 years old	0.2	21	7.0	2.5	0.1	0.01	0.03
253 45-55 years old	0.8	29	7.6	0.5	0.1	0.01	0.03
187 45-55 years old	0.2	19	3.5	0.2	0.3	13.0	0.04
227 45-55 years old	0.5	21	7.2	3.8	0.2	0.01	0.02
169 45- 55 years old	0.9	30	47.0	0.5	0.1	0.01	0.02
236 45-55 years old	0.5	28	24.1	1.0	0.1	0.01	0.03
234 45-55 years old	0.7	27	24.5	0.8	0.3	0.01	0.03
153 55 years oldest	0.6	24	34.7	5.3	0.2	0.01	0.03
201 55 years oldest	0.1	36	10.5	0.3	0.1	0.01	0.03

used to preserve timber for construction purposes. Lead was used in the 15-20th centuries for making household utensils and also for pipes and roof covering. Also, Pb-based paints were widely used from the 15th century on.

Such are the results of our studies of the microelement composition of bone tissue belonging to women buried in the Middle Ages within the Moscow Kremlin and of habitation deposits in some parts of its territory. These data enable us to get an idea of the environment of palatial chambers where Russian ladies spent their life; in some cases we can learn the true causes of their death. However, an understanding of all the factors impacting people's life requires, first, a more representative sample of data, and second, research findings on the remains of the urban population of different social and age groups. Relevant studies are underway now.

The data given in Table 6 may serve to illustrate some of the complexities. They show a more complex micro-element composition of the bone tissue of men buried within the Kremlin and the St. Andronicus monastery compared with corresponding data on women buried in the vaults of the Ascension Cathedral. Since some of the monks must

Table 8. Microelements in bone tissues of children buried in the Troitsa church (mg/100g of bone tissue).

Objects	**Cu**	**Zn**	**Mn**	**Pb**	**As**	**Ag**	**Hg**
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04	0.04
12-13 years old	0.5	21	21.0	0.5	0.1	0.01	0.02
12-13 years old	0.6	62	23.9	0.9	0.5	0.01	0.03
9-10 years old	0.6	24	6.4	1.5	0.9	0.01	0.03
8-9 years old	1.0	152	315	0.8	0.3	0.01	0.03
6-7 years old	1.6	58	6.8	1.6	0.7	0.01	0.01
5-6 years old	1.0	34	13.1	0.3	0.1	0.01	0.03
1.5 years old	1.2	58	42.0	4.0	0.9	0.01	0.01
1 infant	0.8	61	21.0	4.3	1.2	0.01	0.02

Table 9. Microelements in bone tissues of children buried in the Kremlin (mg/100g of bone tissue).

Objects	Cu	Zn	Mn	Pb	As	Hg
Mean concentration in bone tissue today	1.8	14	10	1.9	0.1	0.04
Grand Princess Mariya, daughter IvanIV infant	3.5	210	64	42.0	0.9	0.09
Princess Anna Belsky, infant	1.8	12	8	12.0	0.4	0.01
Grand Princess Feodosiya, daughter Yrina Godunova 2 years old	27.0	500	6	14.2	0.6	0.2
Grand Princess Pelageya, daughter Alecs. Mich. Romanova infant	3.0	50	20	18.0	0.5	0.04
Princess Maria Staritsca 5-7 years old.	3.9	44.7	15	51.4	8.1	0.11
Princess Anastasiya Staritsca infant	6.8	30.5	3.9	15.9	1.6	0.16
Prince Fyodor Belsky, infant	1.7	23.9	8.4	34.7	1.0	0.02

have been involved with icon painting, their bodies likely accumulated toxic substances contained in the paints they were using.

X–ray fluorescence studies of the remains of children belonging to the families of grand princesses and czars are of considerable interest too (Table 9). They must have been living in an extremely unfavorable geochemical environment, or else have been administered toxic medication. We cannot rule out cases of premeditated poisoning in the course of power struggles at the court of Moscow's sovereigns.

CONCLUSIONS

Soils in the central part of Moscow represent the cultural layer with an average thickness of about 3-5 m (up to 15 m in depressions of the initial relief) and the underlying Holocene buried soil. The cultural layer contains numerous traces of pedogenic processes and weakly developed buried soils. The buried natural soil usually has features attesting to its cultivation or even a well-developed plaggen horizon.

Continuous accumulation of municipal wastes, construction material, paints, and other substances of anthropogenic origin resulted in considerable content of organic substances, carbonates, phosphorus, and pollutants within the cultural layer. Their content at the depth of 1–3 m often exceeds that in the surface layer. Excavation activities can lead to additional input of previously buried contaminants to the surface and serve as additional sources of pollution in the urban environment.

Soils in the Kremlin during the 14-17th centuries were much cleaner, than in the medieval town, where industries were located. Nevertheless, the bones of grand Russian princesses and czarinas contain much higher Pb, Cu, and Hg than bones of women from the town. This reflects the living conditions of highborn women, who used white lead and other toxic elements as cosmetics as well as toxic medications.

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