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Evolution of sedimentation in the Vistula Lagoon of the Baltic Sea due to anthropogenic impact

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ABSTRACT

The work pursued basic objectives: to study the structure of the sedimentary strata, identify the sediment units corresponding to specific sedimentation stages of the late Holocene and evaluate the factors that influenced their formation in the Vistula Lagoon. For the achievement of the goals, well-known methods were used. The thickness of the silt deposits was measured by a hand drill. The grain size analysis of bottom sediments was determined by the mass content of particles of various sizes as a percentage of the test sample mass. The content of the total amount of organic matter in the bottom sediments and the mass loss during calcination was determined by the weight method, the determination of the mineral vivianite was carried out by standard methods accepted in geology. The Research results showed that in the lower part of the cores, organic-rich silts of olive shades are common, formed under the influence of river runoff. The sediment composition in the upper part of the cores is sharply different due to an anthropogenic factor – artificial river runoff regulation. Instead of silty sediments, the lagoon accumulated poorly consolidated, dark gray fine sand and siltstone sediments with small organic matter.

KEYWORDS: sediment cores; sedimentary stratum; sedimentation processes; grain-size parameters; hydrological conditions.

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Evolución de la sedimentación en la Laguna del Vístula del Mar Báltico debido al impacto antropogénico

RESUMEN

El trabajo persiguió objetivos básicos: estudiar la estructura de los estratos sedimentarios, identificar las unidades de sedimentos correspondientes a etapas específicas de sedimentación del Holoceno tardío y evaluar los factores que influyeron en su formación en la Laguna del Vístula. Para el logro de las metas se utilizaron métodos bien conocidos. El espesor de los depósitos de limo se midió con un taladro manual. El análisis del tamaño de grano de los sedimentos del fondo se determinó mediante el contenido de masa de partículas de varios tamaños como porcentaje de la masa de la muestra de prueba. El contenido de la cantidad total de materia orgánica en los sedimentos del fondo y la pérdida de masa durante la calcinación se determinó por el método del peso, la determinación del mineral vivianita se llevó a cabo mediante métodos estándar aceptados en Geología. Los resultados de la investigación mostraron que en la parte inferior de los núcleos, son comunes los limos ricos en materia orgánica de tonos oliva, formados bajo la influencia de la escorrentía de los ríos. La composición de los sedimentos en la parte superior de los núcleos es marcadamente diferente debido a un factor antropogénico: la regulación de la escorrentía de los ríos artificiales. En lugar de sedimentos limosos, la laguna acumuló sedimentos de limolita y arena fina de color gris oscuro poco consolidados con pequeña materia orgánica.

PALABRAS CLAVE: núcleos de sedimentos; estrato sedimentario; procesos de sedimentación; parámetros granulométricos; condiciones hidrológicas.

Introduction

The increased anthropogenic impact on the processes in the coastal sea areas is observed almost everywhere (Marín & Ferrer, 2020; Morales et al, 2021). Researchers are particularly interested in coastal lagoons as unique multi-user systems that concentrate on economic and social activities. For these reasons, lagoons are subject to numerous anthropogenic impacts that can affect their biodiversity, sustainability, or even the functioning of ecosystems. It is shown that almost all currently known factors and sources of negative impact affect coastal ecosystems (Patin 2015; Anthony et al. 2009; Halpern et al. 2008; Razinkovas et al. 2008; GIWA 2005; Dolotov 1996).

The Vistula Lagoon (Figure 1) belongs to non-tidal coastal geosystems with many different economic activity forms (Kjerfve & Magill, 1989). Various factors condition the state of its lithological system. The supply of sedimentary material is regulated by river runoff, coastal abrasion, and marine influence (Kennish 2015), the dynamics of the upper sediment layer is regulated by wind-wave influence, and the tides are systematic run-up phenomena (Blazhchishin 1999; Chubarenko 1994; Blazchishin 1998). An essential component of the lithological system is bottom sediments, which are an essential source of information on climatic, geochemical, and ecological conditions of the water collection and reservoir, and are used as natural indicators of the status of aquatic ecosystems and the scale of anthropogenic impact (Dauvalter 2012; Forstner 1979).

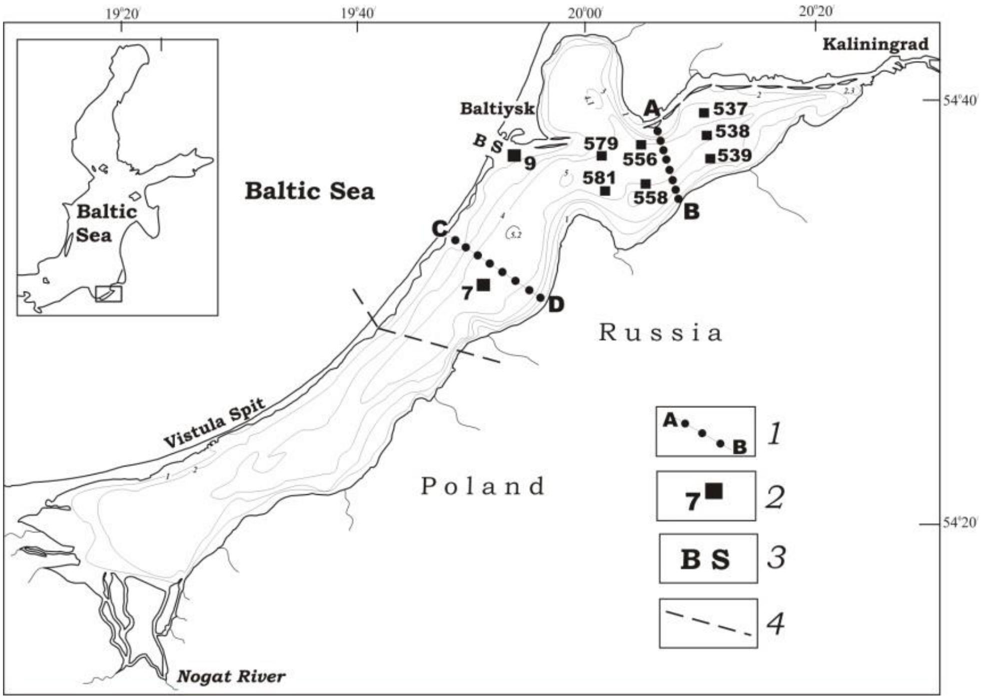

Figure 1. Study area and sediment sampling stations. 1- points for measuring the thickness of silt deposits using a geologist's drill; 2- sediment core sampling points; 3- Baltic strait; 4- position of the Polish-Russian border

In the works devoted to studying the bottom sediments of the Vistula Lagoon, the primary attention was focused, as a rule, on their upper (0–10 cm) layer. The features of the spatial distribution of the main types of sediments on the bottom surface, their granulometric fractions, and the dynamics of the surface layer of bottom sediments were revealed (Szymczak 2019; Chechko 2017). However, the vertical structure of the sedimentary strata has been studied very poorly. Perhaps the only research in this direction in recent years is the work (Chechko et al. 2018).

If the structure and the ratio of the main types of bottom sediments serve as an indicator of the current processes of the lagoon sedimentation, the changes in the cores show the dynamics and direction of the processes of formation and accumulation of lagoon sediments in the historical perspective. The assessment of the morphological structure of bottom sediments in the cores allows identifying the evolutionary stages of the lagoon development and drawing a conclusion about the variability of the sedimentation regime in the lagoon.

Therefore, the author set the following objectives – to study the structure of the sedimentary strata, identify sediment units corresponding to specific stages of Late Holocene sedimentation, and assess the factors that influenced their formation.

1. Study area

The Vistula Lagoon is the second-largest shallow lagoon in the Baltic Sea, with a maximum depth of 5.2 m and an average depth of 2.7 m, which can be classified as an estuarine lagoon without tides (Kjerfve & Magill 1989; Lazarenko & Majewski 1971; Chubarenko et al., 2019; Chubarenko & Margonski 2008). It is located in the south-eastern part of the sea and is separated from it by a narrow sand spit (Figure 1). Water exchange with the sea is carried out through the Baltic Strait and is estuarine; the tides are overrunning phenomena (Blazchishin 1998). This is a transboundary water body. The southwestern part of the lagoon (43.8% of the area) is under Poland's jurisdiction, and the northeastern part (56.2% of the area, Kaliningrad Bay) – under the jurisdiction of Russia, so the results of field studies are given for the Russian part.

From its origin in the early Atlantic period to the beginning of the twentieth century, the Vistula Lagoon was subjected only to natural processes; the determining one was the Vistula River runoff (Witak & Pędziński 2018). A significant part of the sedimentation material brought by the river was deposited in the estuary area of the Nogat River, due to which the mouth was pushed into the lagoon, which made it shallower and smaller (Lazarenko & Majewski 1971; Plit J. 2010). At the turn of the 20th century, an artificial river channel was created, through which 90% of the river flow began to flow directly into the sea.

The determining influence of the Vistula River runoff on hydrological cycles, suspension dynamics, sedimentation, and other sedimentation processes has decreased.

Simultaneously, the influence of the Baltic Sea significantly increased, and the lagoon salinity increased to 3.5–5.0 psu (Chubarenko & Margonski 2008; Matciak & Chyła 2018). Due to the decrease in river flow, the average water level in the lagoon decreased, and the Baltic Sea waters could easily enter it through the strait. Resuspension processes due to wind-wave action take the first place in forming the upper layer of sediments (Ambrosimov et al. 2015; Blazhchishin 1999; Gic-Grusza & Dudkowska 2018). In (Chubarenko 1994), it is shown that resuspension can cover from 40 to 100% of the lagoon water area. The sedimentary material entering the lagoon is not fixed at the bottom immediately; it is repeatedly agitated with the resedimentation of bottom sediments and the partial removal of small fractions through the strait into the sea (Blazhchishin 1999; Szymczak 2019; Chechko 2017; Cieśliński 2013; Chechko V. 2008). In genetic terms, terrigenous sedimentary formations with a large range of dimensions – boulders, gravel, pebbles, mixed-grained sands, siltstones, and silt-pelitic silts are common on the bottom surface of the Vistula Lagoon (Chechko & Blazchishin 2002; Uścinowicz & Zachowicz 1966).

2. Material and methods

Field studies were conducted in the Russian part of the Vistula Lagoon in the summer of 2020. Sediment cores were collected at nine stations (Figure 1). A geological rod tube with a diameter of 72 mm, specially designed for work in shallow water bodies, was used for sampling (Chechko et al. 2019). After lifting the pipe, the core was pushed into the tray, its morphological description and subsequent division into 5-centimeter segments were performed. Samples were taken from each segment to determine the natural humidity, and the rest of the material was packed and sent for laboratory studies.

The thickness of the silt deposits was measured on two transverse profiles (Figure 1) by a hand drill, which was lowered to the bottom and penetrated the bottom sediments. After maximum penetration into the sedimentary strata, the drill was rotated clockwise. Simultaneously, a sediment sample was fixed in the sample receiver at the lower end of the drill. The drill was then removed, a sediment sample was extracted, the length of the drill dive was measured, and the sediment thickness was calculated.

The granulometric analysis of bottom sediments was determined by the mass content of particles of various sizes as a percentage of the test sample mass. It was performed by sieve (fractions › 0.04 mm) and water-mechanical (fractions ‹ 0.04 mm) methods (Budanova et al. 2013). Based on the granulometric analysis results and following the Wentworth classification (Wentworth 1922), the bottom sediments were typified.

The content of the total amount of organic matter in the bottom sediments was determined by the weight method (Heiri et al. 2001) (calcination of a sample of bottom sediments at a temperature of 550 °C). The mass loss during calcination was conventionally taken as the mass fraction of organic matter. The natural moisture content of sediments was determined by weight as the ratio of the mass of water removed from the sample by drying to constant mass to the mass of dry matter of this sample, expressed as a percentage (Methodical…1986). The determination of the mineral vivianite was carried out by standard methods accepted in geology (Ananyeva 2017).

3. Results

Direct measurements of the thickness of the silt layer with a geologist's drill showed that in the middle, the most profound part of the basin, it exceeded 5 meters. As the researchers approached coastal shallow water areas, the thickness of the mud layer decreased; in such cases, the drill completely penetrated it and reached the maternal deposits (Figure 2).

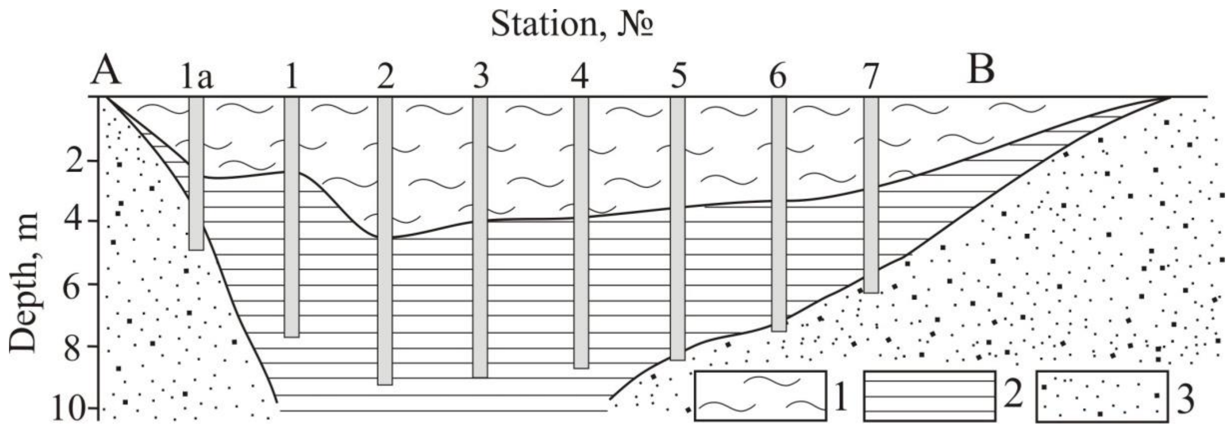

Figure 2. The thickness of the silty deposits, determined using a geologist's drill (location of points is shown in Figure 1). 1-water; 2-silts; 3-maternal deposits

A detailed description of core 556 is given in Table 1 as an example that gives an idea of the vertical structure of the lagoon sedimentary sequence. Based on the sediment composition change, the lower (I) and upper (II) sediment packs are distinguished. Each of them is distinguished by specific features that reflect the specific conditions of sedimentation and allow distinguishing the same divisions in other cores.

Table 1. Description of core 556

Pack No.	Layer No.	Depth from the water surface, cm	Layer thicknes s, cm	Visual lithological description
	1	0–400	400.0	Water
II	2	400–404	4.0	Fine-grained silty, unconsolidated, fluid, dark gray color, strongly watered, with fragments of clamshells and shell detritus sand. On the layer surface, there is a live bivalve *Rangia cuneata*.
	3	404–420	16.0	Fine-grained siltstone, weakly consolidated, dark gray, without visible stratification sand. Apparent bioturbation texture, traces of benthic animals, numerous clam shell fragments, and shell detritus are observed.
	4	420–454	34.0	Soft, dark gray-olive, denser than in the overlying layer, sandy siltstone. Along the entire layer, there are inclusions of shell fragments, shell detritus, their number increases towards the lower part.
	5	454–457	3.0	A cluster of small clamshells, the mineral component is represented by sandy siltstone. The upper and lower contacts are clearly defined.
I	6	457–476	19.0	Homogeneous, vaguely stratified soft fine-aleurite silt of olive-gray color, weakly compacted.
	7	476–477	1.0	An accumulation of small fragments and whole clamshells.
	8	477–515	38.0	Homogeneous, consolidated, vaguely layered, soft fine-aleurite silt of olive-gray color, denser than the sediments of the overlying layers.
	9	515–540	25.0	Homogeneous, consolidated, vaguely layered, soft fine-aleurite silt of olive-gray color, visibly thickening towards the lower part. Small shells and their fragments are randomly scattered throughout the layer.
	10	540–562	22.0	Soft, consolidated, lumpy dark gray-olive fine-aleurite silt. The upper contact is clear, well-defined in color and density.

The thickness of the upper pack ranged from 32 cm (core 580) to 65 cm (core 537) and averaged 50 cm for all cores. In its upper part, watered, unconsolidated, dark gray, fine-grained silty sands with no visible stratification are common. In the lower layers of the second pack, an increase in siltstone and a decrease in sand material were observed in the composition of sediments. Individual clam shell fragments and randomly scattered particles of shell detritus were recorded along the entire pack profile. A characteristic feature of the upper pack is the bioturbation textures detected in all cores. Sometimes under a relatively thin (5–15 cm) layer of sediment, clumps of fragments and whole shells of freshwater clams from 3 to 20 cm were found.

Since the cores did not always reach the maternal deposits, the true thickness of the lower (I) pack was not elucidated and was limited in each case by the core length. Its thickness varied from 73 cm (cores 558, 580) to 102 cm (core 556). The lower pack is represented by denser, consolidated, vaguely layered, soft, olive-colored muddy sediments. Occasionally, the bulk of the sediments contained unevenly scattered rare shell fragments and detritus. The upper contact of the pack is clear, well expressed in color and density characteristics.

The granulometric composition of bottom sediments in the cores is represented by size fractions with a diameter of < 0.5 mm. Based on the prevailing fraction (0.125–0.063 mm), the sediments of the upper pack are dominated by fine and very fine sands, the content of which in the near-surface layers reaches 63%. With the depth of occurrence, the sand content gradually decreases, and in the lower pack layers, it does not exceed 50%. The main impurity is coarse silty (0.063–0.04 mm) material (20–36%) and particles < 0.04 mm (8–20%).

In the sediments of the lower pack, sand particles occupy a subordinate position; their content does not exceed 20%. The predominant siltstone material (average 73%) with a high proportion (average 15%) of clay parts comes out on top. A characteristic feature of the lower pack sediments is uniformity in the vertical distribution of the grain size, without significant changes in the ratio of size fractions.

As noted above, the primary indicator that indirectly characterizes organic matter content in the bottom sediments was taken as the loss during calcination. The calcination losses of the upper pack varied from 2 to 13% and averaged 6% for all cores (Table 2). The minimum (from 2 to 5%) estimated organic content was always observed in the surface (0–

10 cm) layers of the cores. The pack I is characterized by an increase in loss during calcination across the entire profile. The maximum organic matter content reaches 29%, and on average, for all cores, it is 19% (Table 2).

Table 2. Amount of loss on anneal in sediment cores

Layer, cm	**Loss on anneal, % Core, №**								
	537	538	539	556	7	558	579	9	581
0-5	4	4	4	3	3	4	4	3	2
5-10	5	4	6	5	4	4	5	3	3
10-15	4	5	6	5	4	5	5	4	4
15-20	5	5	6	6	6	6	6	4	4
20-25	5	6	7	5	5	5	6	3	6
25-30	6	6	7	5	7	6	8	3	10
30-35	9	6	6	6	7	7	14	4	11
35-40	9	7	7	7	8	9	15	5	13
40-45	10	8	9	10	10	9	15	4	16
45-50	9	8	10	8	10	10	15	3	17
50-55	10	8	9	12	12	10	16	3	18
55-60	12	8	9	14	15	18	15	4	17
60-65	13	15	15	14	18	15	16	4	21
65-70	13	15	16	14	18	16	16	3	19
70-75	13	18	17	13	15	16	20	5	19
75-80	15	19	17	14	16	16	18	4	21
80-85	14	20	19	15	19	17	18	4	20
85-90	14	21	20	15	22	22	17		20
90-95	15	20	20	13	22	20	16		21
95-100	16	20	22	19	24	23	17		23
100-105	16	20	22	18	26	24	19		25
105-110	15	22	27	20	26	24	20		24
110-115	18	27	22	21	24	25	20		27
115-120	18	27	23	17	25	22	22		20
120-125	20	25	27	17	25	23	22		24
125-130	19	23	25	18	26	18	20		26
130-135	19	23	23	20			22		26
135-140	21	22	23	21			22		23
140-145	20			20					
145-150	21			18					
150-155	21			19					
155-160	29			18					

The natural moisture content of the bottom sediments in the upper pack varied from 45 to 90%. Simultaneously, the highest (75–90%) humidity values were always observed in the surface layers, in the "bottom sediments – water" contact area. A decrease in humidity was observed with an increase in the depth of sediments. However, in the lower pack layers, its values again increased markedly.

In the lower pack, sediments were characterized by a consistently high natural humidity, the values of which varied from 90 to 165%. In this case, the humidity values changed slightly with increasing sedimentation depth, gradually decreasing towards the deepest layers of the cores.

Blue ocher (ferric phosphoric acid) was detected in microscopic studies in all cores of the lower packs, in contrast to the surface layers of sediments, in which it was absent. This authigenic mineral occurred as well-defined laminal elongated microcrystals grouped in large weakly split aggregates (sometimes reaching more than 1 cm in diameter) and as powdery crumbly clusters of indigo blue color.

4. Discussion

It is known (Lazarenko & Majewski 1971; Plit 2010) that until the early 20th century, the hydrological and sedimentation regime of the Vistula Lagoon was determined by the river flow, and the primary source of sediment was the Vistula River, which annually supplied to the waters of the lagoon 4–5 times as much sediment as any other river. Built in 1916, water-regulating structures significantly reduced river runoff. Its influence on sedimentation in the lagoon began to weaken; simultaneously, the role of waves and water exchange across the Baltic Strait began to increase (Chechko 2008).

Changes in sedimentation conditions affected the formation of the sedimentary strata, as evidenced by the study results. Despite some differences due to the location of core sampling points, all of them have a similar vertical structure divided into two divisions: lower (I) and upper (II) sediment packs. Such a division indicates that the formation of the sedimentary strata of the lagoon occurred in two stages, each of which corresponded to different sedimentation conditions formed under the influence of various factors.

Judging by the features of the granulometric composition and distribution of organic matter in the lower pack, the main source of sedimentary material during its formation was river runoff. A thin sedimentary material was deposited and accumulated in the lagoon basin, which turned into soft, homogeneous, olive-colored deposits of the lower pack. Their composition is steadily dominated by silty particles (average 73%) for all cores with a high proportion (average about 15%) of clay material. The sand component in the bottom sediments of the lower pack does not take up much space. The uniformity in the vertical distribution of the granulometric composition indicates the constant nature of the sedimentary material entering the lagoon from a single source over a long period.

Human intervention in the hydrological regime caused a sharp change in the sedimentation situation and a significant reduction in the arrival and accumulation of fine sedimentary material in the lagoon. This is reflected in the composition of the upper pack sediments formed after the river runoff regulation. According to the data obtained, its thickness varies from 32 to 65 cm. This is the amount of sedimentation that could have accumulated in the deep places of the lagoon over the past 100 years at a sedimentation rate of about 3.5 mm/year (Chubarenko et al. 2019).

This gives grounds to characterize the sediments common in the upper pack as "modern," i.e., young in historical terms. They are unconsolidated, slightly silted, covered with a thin oxidized film on top of small sands of dark gray shades, with the proportion of an average of 63% (as opposed to 8% in the lower pack). Simultaneously, the content of silty particles significantly decreased – from 73% to 12% (Figure 3). The increase in the sand fraction is probably due to the increased role of coastal abrasion in the sedimentation processes, and the decrease in silt particles is due to the reduction of river runoff and the activation of resuspension processes. It is shown (Blazchishin, 1998; Chechko, 2008) that one of the results of resuspension is washing the upper layer of sediments from fine particles with their partial discharge into the sea or resedimentation in other parts of the lagoon. The absence of layering in the upper pack also indicates the activation of the sediment spreading processes.

It should be noted that the processes of resuspension characteristic of the modern environment are a powerful mechanism for self-purification of bottom sediments. In this case, sorbed mobile forms of heavy metals and other pollutants partially pass from sediments to water, partially with muddy particles are carried out into the sea (Blazhchishin 1999; Blazchishin 1998).

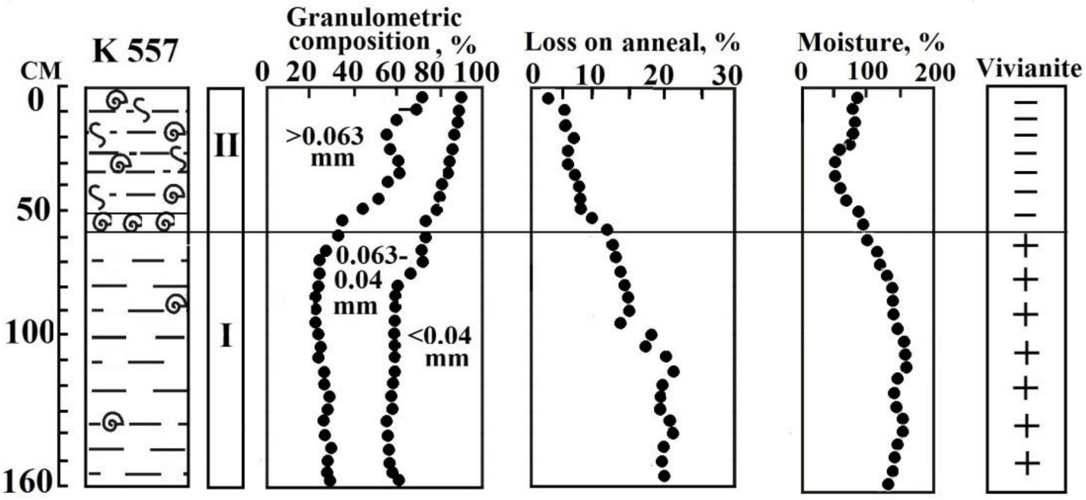

Figure 3. Sedimentological parameters of core 557 (I, II - sediment packs)

A characteristic feature of modern sediments is the presence of bioturbation textures formed by benthic animals' activity (Figure 4). Traces of animals were observed to a depth of 35-40 cm, and in fact, the entire upper pack is a substance for their vital activity. No traces of animals were found in the deeper layers of the sedimentary strata (Ezhova et al. 2005), fragments of clamshells and shell detritus were occasionally found.

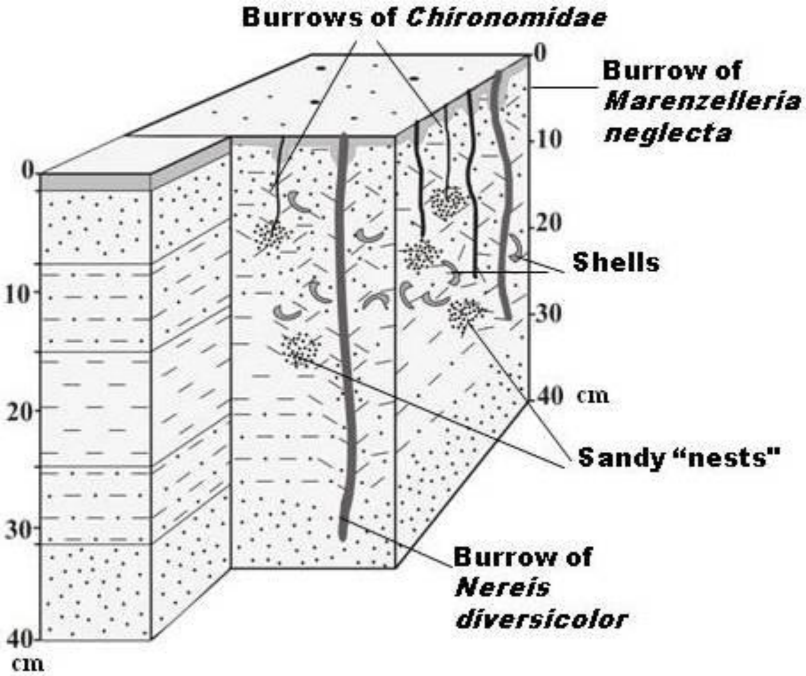

Figure 4. Block diagram illustrating bioturbation of bottom sediments Vistula Lagoon

Regularly in the lower layers of modern sediments, there was an accumulation of fragments and whole shells of freshwater clams, as well as shell detritus. According to the hypothesis (Blazchishin 1998), this is due to a change in hydrological conditions after regulating the runoff of the Vistula River. The increase in the water salinity led to the death of freshwater mollusks and the formation of a characteristic thanatocoenosis in the form of a layer of shell rock. If the hypothesis is confirmed, it can serve as a horizon separating modern sediments and sediments accumulated during river runoff dominance.

Essential features that allow judging changes in sedimentation conditions include the amount of organic matter in the sedimentary strata. In the lower pack, stable high concentrations were found, and in all the cores obtained, they ranged from 13 to 29% (Table 2, Figure 3). The consistent distribution of organic matter over the depth in the lower pack sediments, without interruptions or sharp jumps, indicates that the sedimentation conditions remain unchanged.

The restriction of river runoff has led to an expected reduction in allochthonous organic matter, and the autochthonous material produced in the lagoon plays a minor role in sedimentation. Despite the high productivity of phytoplankton, the main part is dissolved and mineralized; this process continues even after its deposition to the bottom (Emelyanov 2014). Besides, organic particles, being the lightest, may be carried out into the sea when sediments are agitated. As a result, in modern sediments, low organic matter values are noted, which are on average no more than 6% for all cores.

Among the physical properties, the natural moisture of bottom sediments responds commensurately to changes in sedimentation conditions. In the surface (0–10 cm) layer of modern sediments, the highest contents of the upper pack were found (75–90%). This is a typical state of the upper layer of sediments, subject to regular sediment spreading and water saturation.

With an increase in the depth of occurrence, the sediment humidity decreases to 45% but increases again at the lower pack border. In the lower pack, the moisture content of the sediments increases significantly and varies from 145 to 195% (Figure 3). This is due to an increase in sediment dispersion and organic matter saturation since these parameters largely determine the amount of humidity.

Among the indicators of the sedimentation environment of lake-lagoon ecosystems, the blue ocher is considered very convincing. It is formed from organic substances under reducing conditions with oxygen deficiency and indicates anaerobic destruction of organic matter. Probably, similar conditions existed in the lagoon during the period of river runoff dominance since blue ocher aggregates were detected in all the cores of the lower pack (Figure 3). Given the high organic matter content, some of the sedimentary layers of the lower pack can be defined as decay ooze, in which blue ocher has a wide development.

No traces of blue ocher were found in modern sediments, which can be explained by anthropogenic factors. After the river runoff restriction, the average water level in the Vistula Lagoon decreased, and the waters of the Baltic Sea could easily enter the lagoon through the Baltic Strait (Lazarenko & Majewski 1971). The inflow of sea waters and their mixing with the lagoon waters contributed to the oxygen saturation of the entire water strata. Oxidative processes began to dominate at the bottom of the lagoon, as evidenced by the oxidized film on the surface of the bottom sediments.

In the author opinion, the results of the core nine studies can be considered very interesting. Unlike other cores, it was obtained in a semi-open harbor built in the 1930s, i.e., after river runoff restriction. It could be assumed that the core should not contain silts deposited in the lagoon during the period of river runoff dominance. Studies have confirmed this assumption. Up to the underlying sands, modern deposits were identified along the entire core length – dark gray silted fine sands with insignificant organic content, low humidity values, and a complete absence of blue ocher.

Conclusions

As a result of the core study, the lithological and stratigraphic heterogeneity of the sedimentary strata of the lagoon was revealed. This suggested the genesis and dominant influence of factors on Late Holocene sedimentation processes. The data obtained indicate that the formation of the sedimentary strata of the Vistula Lagoon includes two stages: the stage of river runoff dominance and the stage that followed its artificial restriction (modern sedimentation stage).

During the influence of river runoff, mainly soft, fine-aleurite silts of olive shades enriched with organic matter were accumulated in the lagoon basin. According to their composition and properties, some of them can be classified as decay ooze formations. The uniformity of the sediments and the slight changes with depth indicate the duration, continuity, and immutability of the sedimentation conditions.

Under the influence of an anthropogenic factor (artificial restriction of river runoff), sedimentation conditions in the lagoon have radically changed, which resulted in the cessation of the accumulation of olive, organic-enriched silts. Instead, siltstone formations with an admixture of fine-grained sands began to accumulate. They were distinguished by gray color shades, low content of organic substances, and attractive conditions for benthic animals' lives.

Artificial regulation of river runoff has led to a change in the direction of evolution of the Vistula Lagoon as a system in general and a change in its natural sedimentation regime, in particular. The sedimentation situation that has developed under the influence of the anthropogenic factor can be described as favorable. The lagoon is not threatened by waterlogging and contamination of bottom sediments due to the existing effective self-cleaning mechanism.

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