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Evaluation of technogenical load in urbanized territories on the example of Lithuanian cities

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Evaluation of technogenical load in urbanized territories was carried out by segregating technogenical complexes of various character. In the majority of cases, different effects of different technogenical complexes are identical and recurrent. Moreover, impact zones of technogenical loads in a geological environment often overlap and make up the general influence zone. Therefore, the density of objects comprising a technogenical complex and their impact zones determine the intensity of technogenical load on a territory. On large territories containing technogenical complexes of various purposes, technogenical load intensity is measured accounting for various buildings and factories according to their size and the parametric indices of activity. Separate indices are pieced together into a general (total) resultant of total evaluation. Technogenical load maps, the primary aim of which is to reflect the integral external forces influencing the geological environment, were compiled employing this methodological principle. Analysis of technogenical load intensity allowed to evaluate the regularities of this load distribution on urban territories.

Key words: technogenical load, geological environment, urbanization degree, Lithuania

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INTRODUCTION

Human impact on the geological environment in towns is particularly intensive and diverse. The total technogenical effect is determined by technogenical complexes such as industrial and dwelling buildings, hydrotechnical constructions, linear transport, agriculture and mining. Quantitative evaluations of these technogenical complexes provide an opportunity to quantify the integral character of technogenical load, which particularly clearly manifests in urbanized territories. The density of objects of which technogenical complexes consist, and their effect zones are determined by the intensity of technogenical load. On the other hand, territories of towns of the Lithuanian Republic, which differ in the level of urbanization and in engineering geological conditions, are a proper ground for evaluating the interaction of the human engineering economical activity and geological environment and its outcome.

Analysis of technogenical load intensity and its distribution in urban areas is performed on the grounds of technogenical load maps of Vilnius and Šiauliai central parts, compiled by the author (Gadeikytė, 2007) and using also the previously compiled (Gadeikis, 1998) map of the technogenical load in Klaipėda. These cities were chosen not incidentally. They differ not only in their geographic location in respect of Lithuanian area, but also in engineering geological conditions (ground, groundwater, relief, geological processes) and a variety of objects of technogenical complexes (residential, industrial, hydrotechnical, mining, agricultural, linear transport). This provides a possibility to establish the regularities of the distribution of technogenical load on the city territories and to analyse the results.

METHODS OF TECHNOGENICAL LOAD MAPPING

The level of urbanization in a territory is the main mapping element of a technogenical load map. Various criteria, the number of which by different authors is indicated as 2–3 to 30 and more, are applied to evaluate this degree (Котлов и др., 1989; Шубин, 1987; McMahon, Cuffney, 2000; Coles, Cuffney et al., 2004). Their portrayal and evaluation in 2D type cartographical material causes a number of inconveniencies for an information user (Matula et al., 1981). Therefore, it is purposeful to present the primary scalar information resumptively, applying multidimensional a system of coordinates for evaluation. By subtracting the values of various information indices on the corresponding axes of reference and joining the derived points among themselves, a polygon of partial values is made. Nominally, evaluation of polygon position from the beginning of coordinates (zero reference point) is done in the size of the general resultant which starts at the beginning of coordinates and runs athwart the polygon center and herewith is normalized both in respect of the zero point and the maximum polygon.

While using various scale cartographical material of urbanized territories for technogenical load mapping, it is advisable to use 2–3 criteria of the urbanization evaluation – the density of the civil and industrial constructions and linear transport technogenical complexes in a unit of the area (Dundulis et al., 1995). On large scale maps, the above-mentioned complexes are expressed in area units. So, when equalizing the principles of cartographical expression, it is advisable to use comparative units showing how a particular value differs from the maximum level of urbanization in a unit of the area. When series of calculations were performed in different urbanized territories of Lithuania (Vilnius, Kaunas, Klaipėda) it was established that the maximum density of buildings makes 68.5% and with linear transport straights 66.5% in an area unit. When accepting this information for the maximum level of urbanization, i. e. as equal to unity, we can express both the mapping sizes of buildings and straights using comparative values (in unit parts) and herewith to equalize their parameter expression. In this way, the two urbanization level constituents having the same expressions are received. This provides an opportunity, with the help of a two-dimensional planar solution, to figure out the total evaluation resultant *c* by the formula:

$$c = \sqrt{a_{xy}^{2} + b_{yx}^{2}},$$

here

c – total evaluation resultant, units, d.;

a_{xy} – relative area of built up territory, units, d.;

b_{yx} – relative area of extended linear buildings, units, d.

For evaluating the intensity of territory urbanization, the data model of the regular grid was used, in which a particular territory is divided into spaces (squares) of equal sizes and every square has an average value of the analysed parameter. Thus, using a 1 : 10 000 topographical map scale kilometer grid, the territory was divided into elements of 100 × 100 m. Every element was given a number which corresponded to the horizontal and vertical number of the kilometrical grid and to a serial number of the element. The level of this elementary area in case of the maximum built up territory makes 100%. The total evaluation resultant of two above-mentioned urbanization level constituents was figured out by a formula (Dundulis et al., 1995).

Segmentation of urbanization degree calculated by the above formula for areas, with a minute technogenical load is carried out in more detail than for urbanized territories. On this basis, the following segregation scale is selected: 0–10%, 10–20%, 20–40%, 40–60%, 60–80%, 80–100% of constituents from their maximum value. While describing the technogenical load in the territories of towns in detail, the residential domestic and industrial construction complexes are distinguished, in them the elementary areas of the map are presented in a different colour chord: in a residential complex jade-yellow-brown and in an industrial complex brownish-red-blue (Dundulis et al., 1995).

Using scale marks, the watering-place territories, graveyards are depicted. In the zone of an industrial complex, the non-scale marks are presented, which indicate the production manufactured by the companies or the peculiarities of the technological process. The gas stations are additionally marked in the map. This information allows to measure the potential pollution of some objects in case of an accident.

Technogenical load map is made using Map Info from the following information layers: topographer base, technogenical load intensity distribution net, scale objects (graveyards, watering-place territories, routes), non-scale objects (gas stations, industry). The map is provided with a computer variant of technogenical load intensity cadastre in Windows Excel software. The following data are presented for each elementary area in the cadastre: • elementary area number; • built up area, %; • separately the area of streets, roads and railroads, %; • total area of linear objects, %; • territory built up degree, %; • additional data (non-scale objects) indicating the specificity; • colour, corresponding to the built up degree in a legend, number.

A digitized variant of the technogenical load map ("on-duty" map) and the technogenical load cadastre are stored in computer database, in order to adjust and revise them eventually and in case the technogenical situation undergoes changes.

EVALUATION OF TECHNOGENICAL LOAD ON THE EXAMPLE OF VILNIUS, ŠIAULIAI AND KLAIPĖDA

Three urbanized territories in different geographical and engineering geological conditions were chosen for technogenical load evaluation. These are the central parts of the Klaipėda, Vilnius and Šiauliai cities (Fig. 1). The evaluation has shown that the general intensity of technogenical load by evaluating the density of all civil, industrial and linear transport complexes of a city varies from 15 to 25% (low and medium). However, evaluation of the territories without areas in which the intensity of technogenical load is equal to 0% (parks, squares, blank areas) and repeated calculations for the rest of the territory have revealed that here the intensity of technogenical load increases to 23–33% (medium). Individually calculating the build-up degree of the industrial and residential territories with recreational zones, the average build-up degree of the industrial zones of these cities varies from 20% to 39% (medium), and civil from 13% (low) to 22% (medium). The intensity of technogenical load in the territories of residential domestic construction without the recreational zones and blank areas increases to 21–30% (medium).

According to the generalized score of technogenical load, the study areas are characterized by a similar regularity of the distribution of technogenical load (Fig. 2).

In most of the areas of the cities, the technogenical load is very low (<10%). These are recreation areas, graveyard territories, unbuilt areas on the banks of reservoirs and city outskirts, territories unsuitable for construction. The load of 20–40% was established in a wide range of streets and dense railroad networks (railing only), in denser housing areas, private construction areas and central parts of the cities. In industrial zones, the load is caused by bigger buildings and parking lots. Further, in descending order go territories whose load intensity is low (10–20%), high (40–60%), very high (60–80%) and extremely high (80–100%).

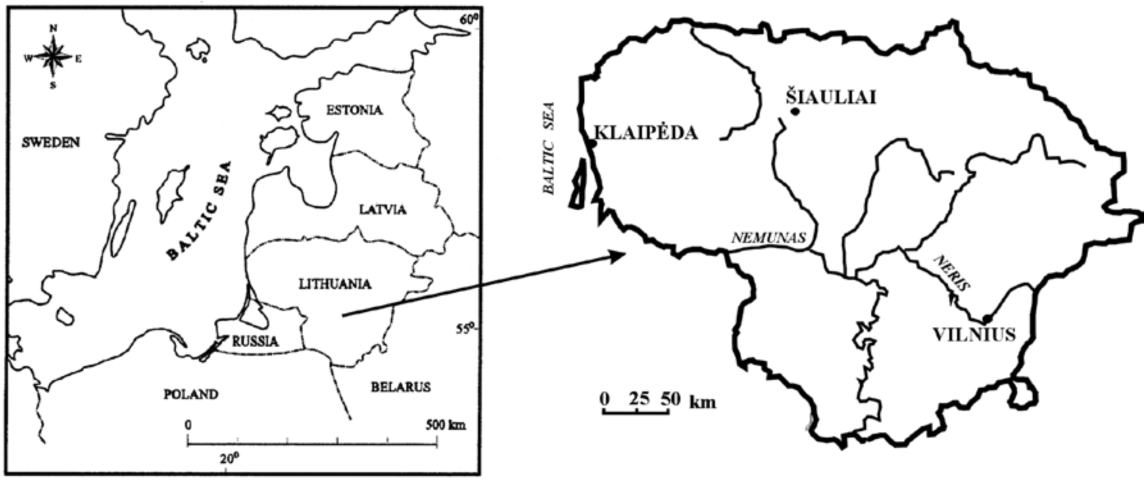

Fig. 1. Situational chart of geographic location of the study cities
1 pav. Situacinė miestų geografinės padėties schema

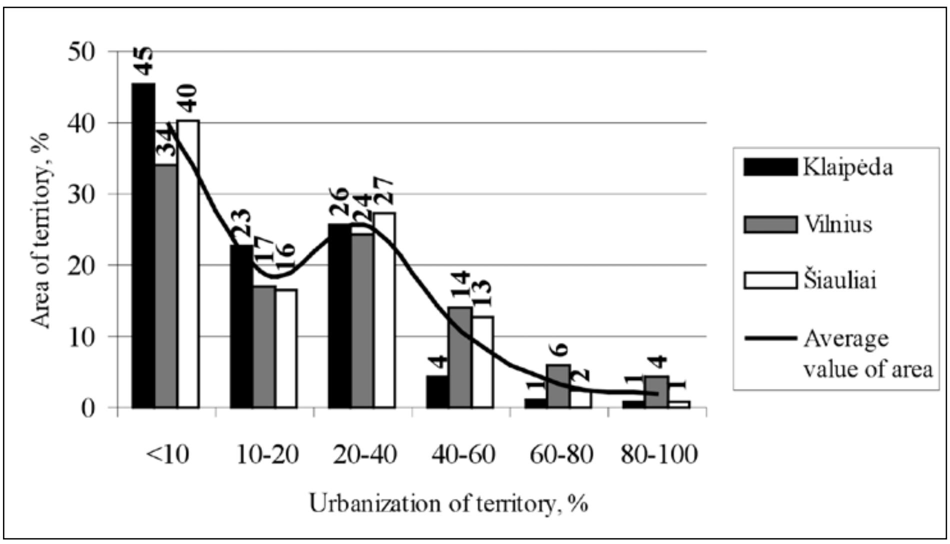

Fig. 2. Technological load intensity distribution on study areas
2 pav. Technogeninės apkrovos intensyvumo pasiskirstymas etaloniniuose plotuose

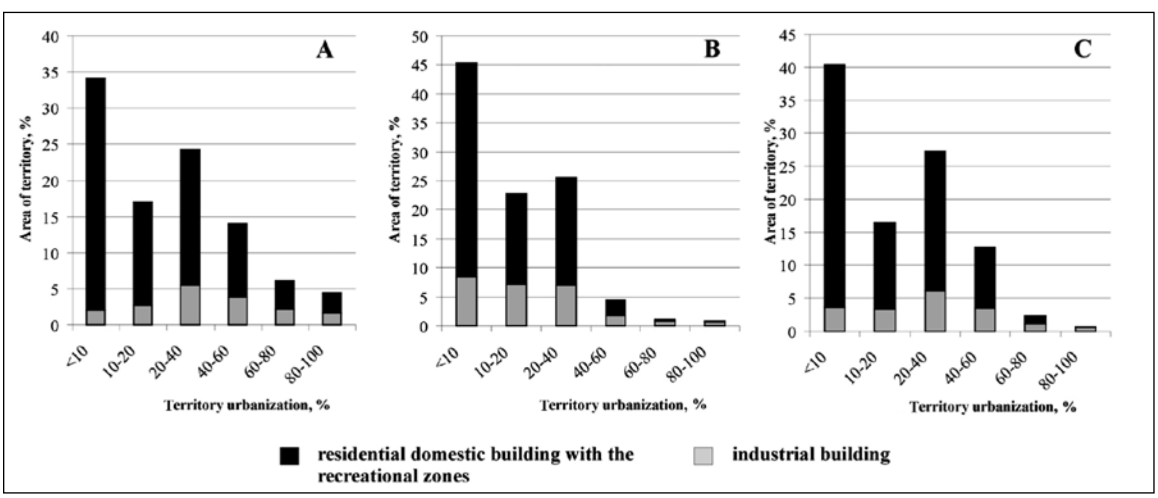

Fig. 3. Distribution of industrial and civil construction with recreational zones at under different technogenical load: *A* – in Vilnius, *B* – in Klaipėda, *C* – in Šiauliai
3 pav. Pramoninės bei civilinės statybos su rekreacinėmis zonomis pasiskirstymas esant skirtingai technogeninei apkrovai: *A* – Vilniuje, *B* – Klaipėdoje, *C* – Šiauliuose

Table 1. **Distribution of technogenical mechanical effects depending on building type under different technogenical loads**
1 lentelė. **Technogeninių mechaninių poveikių pasiskirstymas priklausomai nuo statybos rūšies esant skirtingam technogeninės apkrovos laipsniui**

Technognical load intensity, %	Types of technogenical mechanical effects			
	Static loads of buildings		Vibration	
	Residential complex	Industrial complex	Residential complex	Industrial complex
Average, 20–40	+	++	++	+
High, 40–60	+	++	++	+
Very high, 60–80	+(+)	++	++	+(+)
Extremely high, 80–100	+(+)	++	++	+(+)

++ – prevailing effect; + – side effect; +(+) – effect contiguous to prevailing or prevailing with regard to other effect.

Table 2. **Prognosis of changes in geological environment and their influence on buildings caused by technogenical mechanical load under technogenical load of different intensity**
2 lentelė. **Technogeninės mechaninės apkrovos sukeltų geologinės aplinkos pokyčių bei jų įtakos statiniams prognozė esant skirtingam technogeninės apkrovos intensyvumui**

Intensity of technogenical load, %	Occupied area	Characteristics of the technogenical complex	Mechanical technogenical effects and the character of their exertion	
			Static load	Vibration
1	2	3	4	5
Very low, <10	Takes up 34–45% of the town territory	Recreational areas, cemeteries, watering places, water bodies, unbuilt areas next to water bodies, undeveloped territories on the outskirts of towns, areas unsuitable for building works	Effects on geological environment are minimal or no none	
Low, 10–20	Takes up 16–23% of the town territory	Intermediate zone between the areas with very low and medium intensity of technogenical load, single buildings or small groups of them, short ranges of narrow streets covered with asphalt, sparsely built up individual building areas, single homesteads on the outskirts of towns	Average static loads transmitted by buildings vary from a few tens up to a few hundreds of kPa. These are single buildings usually at a good distance from each other; therefore their interaction is not probable	Transport traffic intensity is not high. Intensity of vibration depends on strength characteristics of the soil comprising the base of the streets, and on the transport. Buildings are far from the street, therefore vibration has no influence on them.
Medium, 20–40	Takes up 24–271% of the city territory	Sections of wide streets covered with asphalt, residential regions (multistory and individual buildings); big single buildings, technical yards, access roads, single railway lines in industrial regions	Average static loads transmitted by buildings vary from a few tens up to a few hundreds of kPa and even more. Buildings are at a good distance from each other, therefore their interaction is not probable	Transport traffic intensity is quite high. The impact of vibration depends on strength characteristics of the soil comprising the base of the streets and on the transport. In buildings situated near street, vibration caused by transport traffic is registered
High, 40–60	Takes up 4–14% of the city territory	Dense street and road network with single buildings in residential regions, in the historical parts of the towns – sections of wide streets (covered with asphalt or stone blocks) with rather densely situated buildings; in industrial regions, the territories of large industrial objects, access roads, railways (several lines)	Average static loads transmitted by buildings vary from a few tens up to a few hundreds of kPa. Buildings are situated rather densely, therefore their general settlement can manifest itself	Transport traffic intensity is high. The impact-vibration effect depends on strength characteristics of the soil comprising the base of the streets, on the transport, the sort of street pavement and its abrasion degree. In the buildings which are situated near streets, vibration caused by transport traffic is registered
Very high, 60–80	Takes up 1–6% of the city territory	In residential regions – a dense network of large highways or dense build-up with big buildings, with short ranges of narrow streets usually covered with stove blocks (historical town parts); very big industrial objects, territories of railway depots in industrial regions	Average static loads transmitted by buildings vary from a few tens up to a few hundreds of kPa and even more. The arrangement of buildings is dense. General settlement depressions of building groups are developing	Transport traffic is intense and of various kind. Intensity of the impact-vibration effect depends on strength characteristics of the soil comprising the base of the streets and on the transport kind, street pavement and its abrasion degree. In the buildings situated close to the street, vibration caused by traffic is registered
Extremely high, 80–100	Takes up 1–4% of the city territory	In the residential regions a very dense build-up with large buildings, with short ranges of narrow streets usually covered with stove blocks (historical town parts); very large industrial objects in industrial regions (take up almost or the whole area of an elementary area), railway depot territories (very dense network of railways in the whole elementary area)	Average static loads transmitted by buildings vary from a few tens up to a few hundreds of kPa. The arrangement of buildings is dense. General settlement depressions of building groups are developing	Very intense transport of various kind where the traffic is not restricted. Intensity of impact-vibration depends on strength characteristics of the soil comprising the base of the streets and on the transport kind, street pavement and its abrasion degree. In buildings situated close to the street, vibration caused by traffic is registered

Territories of the low (10–20%) technogenical load intensity occupy intermediary zones between the areas of very low and medium load intensity or the areas, both in industrial and civil zones, where small buildings or short ranges of narrow streets occur. Moreover, load of this intensity is typical of territories with single homesteads (in city outskirts), ranges of narrow streets, and areas in the centre of the cities, which are rarely built up with small size buildings. The high (40–60%), very high (60–80%) and extremely high (80–100%) technogenical load intensity is related with a dense network of streets, roads and railroads, big civil and industrial objects. In residential domestic areas, these are the centres of cities and multilane streets, roads and railroad lanes; in industrial zones, these are access roads, railroads, territories covered by big industrial objects. Very high and extremely high technogenical load intensity stripes are characterized by very big industrial and civil objects which cover almost the whole elementary area, railway stations and depots with a very dense railway network on the whole elementary area.

The percentage number of the constructional areas of different purpose is distributed regularly when there is different technogenical load intensity in the territories of towns (Fig. 3). Residential buildings with recreational zones make up the biggest part of technogenical load, and its intensity varies from very low (<10%) to high (40–60%). That can be explained by the fact that buildings of this kind usually take up a small-scale part of an elementary area and, as a rule, are surrounded by green and recreational areas of various size and purpose. The prevailing position of this kind of buildings in Vilnius is determined by the large, densely built up area of the historical part of the city where the intensity of the technogenical load is very high and extremely high. In all three cities the area under industrial buildings in the intensity of thechnogenical load increases from very high (60–80%) up to extremely high (80–100%), mainly because of the large area occupied by industrial buildings and a large density of industrial objects of other purposes which surround it (roads, railways, technical yards, smaller buildings).

Changes in hydrostatic pressure	Possible changes in geological environment and their outcome	Recommendations
6	7	8
The highest decrease of the groundwater level is recorded in the territories of watering places (can be up to 60 m). In the remaining territory, the possibility and intensity of the impact depends on whether it fells into the impact zone of watering-place exploitation (if the watering places exploit the pressure of aqueous horizons of the quaternary intermoraine)	Due to mechanical technogenical effects the natural geological processes can become active (slumps, landslides, karsts, suffosion, etc.). Due to the reduction of hydrostatic pressure, the hydrostatic, hydrodynamic and dehydrational soil pressure increases, the thickening of the sandy and sandy-gravelly soils appears, settlement depressions develop. Uneven settlement of buildings is possible	Before reclaiming the new territories, a detailed engineering geological research must be performed. In areas of other purposes, to perform the registration and monitoring of the developing or active geological processes and, if possible, to eliminate the sources of these processes
The probability of impact and its intensity depend on whether the territory is in the impact zone of watering-place exploitation. Due to new construction works, local cases of hydrostatic pressure degression appear	The thickening of soil caused by static load under the buildings, by hydrolithogenic processes, uneven thickening of soils and changes in their strength characteristics due to vibration. Due to the mechanical technogenical effects the natural geological processes can become active (slumps, landslides, karsts, suffosion, etc.). The uneven settlement of buildings is possible	With increasing the build-up degree of the territory, to consider its previous build-up experience and perform additional detailed engineering geological research. Considering the local engineering geological conditions, to use the appropriate field research and construction work methods, in order not to damage the stability of the existing buildings
The probability and intensity of impact depend on whether the territory is in the zone of watering place exploitation. Due to new construction works, local cases of hydrostatic pressure degression appear	The thickening of soil, caused by the static load under the buildings, by hydrolithogenic processes, uneven thickening of soils and changes in their strength characteristics due to vibration. Due to the mechanical technogenical effects, natural geological processes can become active (slumps, landslides, karsts, suffosion, etc.). Uneven settlement of buildings is possible	By increasing the build-up degree of the territory, the same recommendations as for the very low and low intensity of technogenical load. Due to the transport noise it is recommended to make sprout strips, to install antinoise screens or embankments between the buildings and streets. For the buildings situated near street, to protect them from the impact-vibration effect, concrete walls, trenches, canals, etc. must be installed in the soil.
The probability and intensity of impact depend on whether the territory is in the zone of a watering-place exploitation effect. Due to new construction works, installation of continuous artificial pavements, sewerage and drainage, hydrostatic pressure degression appears	The thickening of soil caused by the static load under the buildings, hydrolithogenic processes, uneven thickening of soils and changes in their strength characteristics due to vibration load. Due to mechanical technogenical effects the natural geological processes can become active (slumps, landslides, karsts, suffosion, etc.). Uneven settlement and deformations of buildings (some buildings are in critical condition)	By increasing the build-up degree of the territory (what is not advisable), not to use the technologies causing large-scale vibrations when the engineering geological studies and building works are performed. To reduce the traffic or to limit its speed. To improve street pavement. To protect street buildings situated close to the from the impact-vibration effect, concrete walls must be installed in the soil
The probability and intensity of load depends on whether the territory is in the zone of watering-place exploitation effect. Due to installation of continuous artificial pavements, sewerage and drainage, hydrostatic pressure degression appears	The thickening of soil caused by the static load under the buildings, by hydrolithogenic processes, uneven thickening of soils and changes in their strength characteristics due to vibration. The uneven settlement and deformations of buildings (some buildings are in critical condition)	It is not recommended to increase the build-up degree in the historical parts of the towns. To organize traffic in these territories (to reduce the traffic or to limit its speed) or to prohibit it completely. To improve the street pavement. For buildings close to the near streets, to protect them from vibration, to use all necessary means (to install concrete walls in the soil, to make protective trenches, special gaskets between foundations and above-ground building parts, etc.). To perform the preservation works (registration of the deformations, their monitoring, repair, etc.) on the important buildings
The probability and intensity of load depends on whether the territory is in the zone of watering-place exploitation effect. Due to installation of continuous artificial pavements, sewerage and drainage, hydrostatic pressure degression appears	The thickening of soil caused by the static load under the buildings, by hydrolithogenic processes, uneven thickening of soils and changes in their strength characteristics due to vibration. The uneven settlement and deformations of buildings (some buildings are in critical condition)	Recommendations as for the very high intensity of technogenical load

When all the above-mentioned data were analysed, the presumption was made that in cities, in their areas occupied by residential and industrial complexes, when the intensity of the technogenical load is equal, the technogenical mechanical effects of different kind show themselves not equally. Therefore, the intensity of these effects is directly related to and regularly increases with the growth of technogenical load intensity. At a very low load intensity (<10%) which is usually determined by the absence of engineering buildings of various purpose, the influence of technogenical mechanical effects on the geological environment is minimal or does not manifest at all. On territories with a low technogenical load intensity (10–20%), technogenical mechanical impacts do not reach destructive levels, either. In both cases and independently of the complex territory in which an area is investigated, the possibility of technogenical mechanical impacts of various types and the influence on geological load may be the same.

When the load intensity increases from average (20–40%) to very high (80–100%) in the residential and industrial complexes, the prevailing and side technogenical mechanical effects appear (Table 1). This is determined by the nature of the prevailing building works in an elementary place: various buildings are directly connected with the static load, while streets and roads – with vibration load.

In all the above mentioned cases, independently of technogenical load intensity and construction type, the impact of groundwater level decrease on the geological environment may appear. This effect and its intensity directly depend upon the fact whether a territory falls into an watering-place operation effect zone, and if so, on what part of it and what watery horizons it exploits. Changes of the local hydrostatic pressure may appear in underground engineering construction places.

This distribution of different technogenical mechanical impacts has been established by mathematical evaluation of an area of the dominating construction type at a different degree of a territory build-up. Data provided in Table 1 reflect the average distribution of these effects. Under ordinary conditions, the type and intensity of the dominating technogenical mechanical impact may be determined by a number of environmental factors (engineering geological conditions, traffic intensity and dominating type, loads transferred, etc.). Consequently, in order to evaluate in detail changes of the natural-technical system in an elementary area additional investigations are needed.

The prognosis of geological environment changes caused by technogenical mechanical load and their impact on buildings under different technogenical load intensity is presented in Table 2.

On the basis of Tables 1 and 2 and the compiled maps of technogenical load, the zoning of the study territory by dominating technogenical effects may be carried out and the possible geological environment changes of this territory may be predicted.

CONCLUSIONS

In our case, two urbanization evaluation criteria – the density per unit of area of civil and industrial constructional objects and linear transport technogenical complexes – were used to compile the technogenical load maps. This methodological principle makes the basis for further researches to focus on the multidimensional factors that determine a technogenical load.

With time, the distribution and intensity of technogenical load on the territories of cities has changed significantly and is still changing. With the expansion of towns and mastering of new territories whose technogenical load intensity under ordinary conditions is 0%, with the reconstruction of central parts of towns and carrying out construction works on free areas of built up territories, technogenical load intensity grows tendentiously – from the lowest towards a higher. Digitizing of technogenical load maps allows an efficient response to build-up degree changes on the territories of towns and the upgrading of information provided on the maps. Moreover, with the knowledge of city engineering geological conditions, a comprehensive cognition of the interaction between technogenical load and geological environment is possible. Peculiarities of geological conditions allow to forecast the influence of technogenical load on geological environment and *vice versa* – the influence of geological environment on the behaviour of technogenical complexes.

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TECHNOGENINĖS APKROVOS VERTINIMAS URBANIZUOTOSE TERITORIJOSE REMIANTIS LIETUVOS MIESTAIS

Santrauka

Miestuose žmogaus veiklos įtaka geologinei aplinkai ypač intensyvi ir įvairiapusė. Technogeninio poveikio visumą nulemia dėl žmogaus veiklos susiformavę technogeniniai kompleksai – pramoninės ir gyvenamosios statybos, hidrotechninės statybos, transportas, žemės ūkis bei kasyba. Daugeliu atvejų skirtingų technogeninių kompleksų poveikis yra tapatus, besikartojantis. Be to, technogeninės apkrovos zonos geologinėje aplinkoje dažniausiai persidengia ir sudaro bendrą poveikio zoną. Todėl galima teigti, kad technogeninius kompleksus sudarančių objektų ir jų poveikio zonų tankis nulemia teritorijos technogeninės apkrovos intensyvumą. Didelėse teritorijose, kuriose yra daug skirtingos paskirties technogeninių kompleksų, technogeninės apkrovos intensyvumą įvertiname pagal minėtų kompleksų dydį, ilgį ir jų veiklos parametrus. Atskiri rodikliai sumuojami ir apskaičiuojamas bendras įvertinimas. Šiuo metodologiniu principu buvo sudaryti Klaipėdos, Šiaulių ir Vilniaus miestų centrinių dalių technogeninės apkrovos žemėlapiai. Gauta technogeninės apkrovos intensyvumo duomenų analizė leido įvertinti šios apkrovos pasiskirstymo miestų teritorijose dėsningumus. Gyvenamojo ir pramoninio kompleksų užimamuose plotuose, esant vienodam technogeninės apkrovos intensyvumui, skirtingos rūšies technogeninis mechaninis poveikis pasireiškia nevienodai. Esant labai mažam (< 10%) ir mažam (10–20%) šios apkrovos intensyvumui, technogeninis mechaninis poveikis geologinei aplinkai minimalus arba iš viso nepasireiškia. Apkrovai intensyvėjant nuo vidutinės (20–40%) iki ypač didelės (80–100%), gyvenamajame ir pramoniniame kompleksuose išsiskiria pagrindinis ir šalutinis technogeninis mechaninis poveikis. Tai nulemia vyraujančios statybos pobūdis: įvairūs pastatai tiesiogiai susiję su statine apkrova, o gatvės ir keliai – su smūgine vibracine apkrova. Visais paminėtais atvejais gali pasireikšti požeminio vandens lygio pažemėjimo įtaka geologinei aplinkai.

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ОЦЕНКА ТЕХНОГЕННОЙ НАГРУЗКИ В УРБАНИЗИРОВАННЫЕ ТЕРРИТОРИИ НА ПРИМЕРЕ ГОРОДОВ ЛИТВЫ

Резюме

Влияние человеческой деятельности на геологическую среду на территории города особенно интенсивно и многогранно. Совокупность техногенных воздействий составляют сформированные деятельностью человека техногенные комплексы – промышленное и жилищное строительство, гидротехническое строительство, линейное транспортное, сельское хозяйство и горная промышленность. Во многих случаях воздействие различных техногенных комплексов одинаковое, повторяющееся. Кроме того, зоны воздействия техногенной нагрузки в геологической среде часто перекрываются и составляют общую зону влияния. Поэтому можно предположить, что плотность объектов и их зон воздействий, составляющих техногенные комплексы, определяет интенсивность техногенной нагрузки на данной территории. На больших территориях, где много техногенных комплексов разного типа, интенсивность техногенной нагрузки определялась по размеру, длине и параметрическим показателям вышеназванных комплексов. Отдельные показатели сводятся к суммарному (общему) путем расчета перпендикуляра общей оценки. На основе этого методологического принципа были составлены карты техногенной нагрузки города Клайпеда, центральных частей городов Шяуляй и Вильнюс. Анализ полученных данных техногенной нагрузки позволил оценить закономерности распределения этой нагрузки на территориях городов. На основе полученных результатов было сделано предположение о том, что на участках промышленного и жилищного комплексов при одинаковой техногенной нагрузке разные техногенные механические воздействия проявляются не одинаково. При очень низкой (<10%) и низкой (10–20%) интенсивности такой нагрузки влияние техногенных механических воздействий на геологическую среду минимально или совсем не проявляется. При повышении интенсивности от средней (20–40%) до особенно высокой (80–100%) в жилищных и промышленных комплексах выделяются основные и косвенные техногенные механические воздействия. Это определяет доминирующий вид строительства на выделенном элементарном участке: разные здания напрямую связаны со статической нагрузкой, а улицы и дороги – с ударно вибрационной нагрузкой. Во всех случаях может проявиться влияние понижения уровня подземных вод на геологическую среду.