Dynamics of organic matter levels in fresh groundwater bodies of Lithuania

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Juodkazis V., Klimas A. Dynamics of organic matter levels in fresh groundwater bodies of Lithuania. *Geologija*. Vilnius. 2003. No. 43. P. 20–28. ISSN 1392-110X.

In Lithuania, centralised water supply is based only on groundwater, which after restoration of Lithuania's independence and changes in economic structure is consumed in volumes nearly thrice as low as before. Therefore the conditions of groundwater formation and its quality have changed. Organic matter is a highly important factor of groundwater quality: firstly, its content and the concentrations of some organic compounds in drinking water are limited by the EU-Water Framework Directive; and secondly, by consuming a large part of oxygen used in the oxidation process organic matter changes the hydrogeochemical medium in the aquifers and favours the redox processes. Hence, the content of ammonium, iron, manganese, hydrogen sulphide and other limiting components increases above the permissible levels, and thus water becomes unsuitable for drinking.

Based on a long-term monitoring of 27 wellfields, the article describes conditions of organic matter entering groundwater and the dependence of its concentration on the wellfield exploitation regime.

Keywords: organic matter, fresh groundwater, chemical oxygen demand

Received 13 March 2003, accepted 26 March 2003
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INTRODUCTION

The problem of drinking water has been actual for mankind in all periods of its development, but it became especially urgent after World War II, when the ruined towns had to be rebuilt and new industrial units were created. The prospecting of water resources and its use in water supply systems showed that fresh groundwater was the best option. Therefore, in the second half of 20th century numerous hydrogeological investigations were carried out with the purpose to find the most favourable sites of groundwater extraction to meet the demands of centralised water supply of towns and cities.

As a rule, fresh groundwater meets the requirements for drinking water according to all components, except for iron, manganese and, rarer, fluorine. Therefore, for some time the opinion prevailed that there were no special problems with groundwater quality. However, the experience of the last decades showed that due to constant pollution of the natural environment some hazardous compounds, including organic matter (OM), enter the aquifers.

Organic matter (OM), which is analysed in the present paper in relation to its impact on groundwater quality, is important from two standpoints. Firstly, OM content in drinking water is limited by EU-Water Framework Directive, since higher OM levels in drinking water deteriorate its organoleptic qualities (taste, colour and turbidity), whereas toxic organic compounds involve the risk of chronic diseases. Secondly, by consuming a significant part of oxygen OM changes the hydrochemical medium in the aquifers and thus favours the redox processes, which enhance the levels of several com-

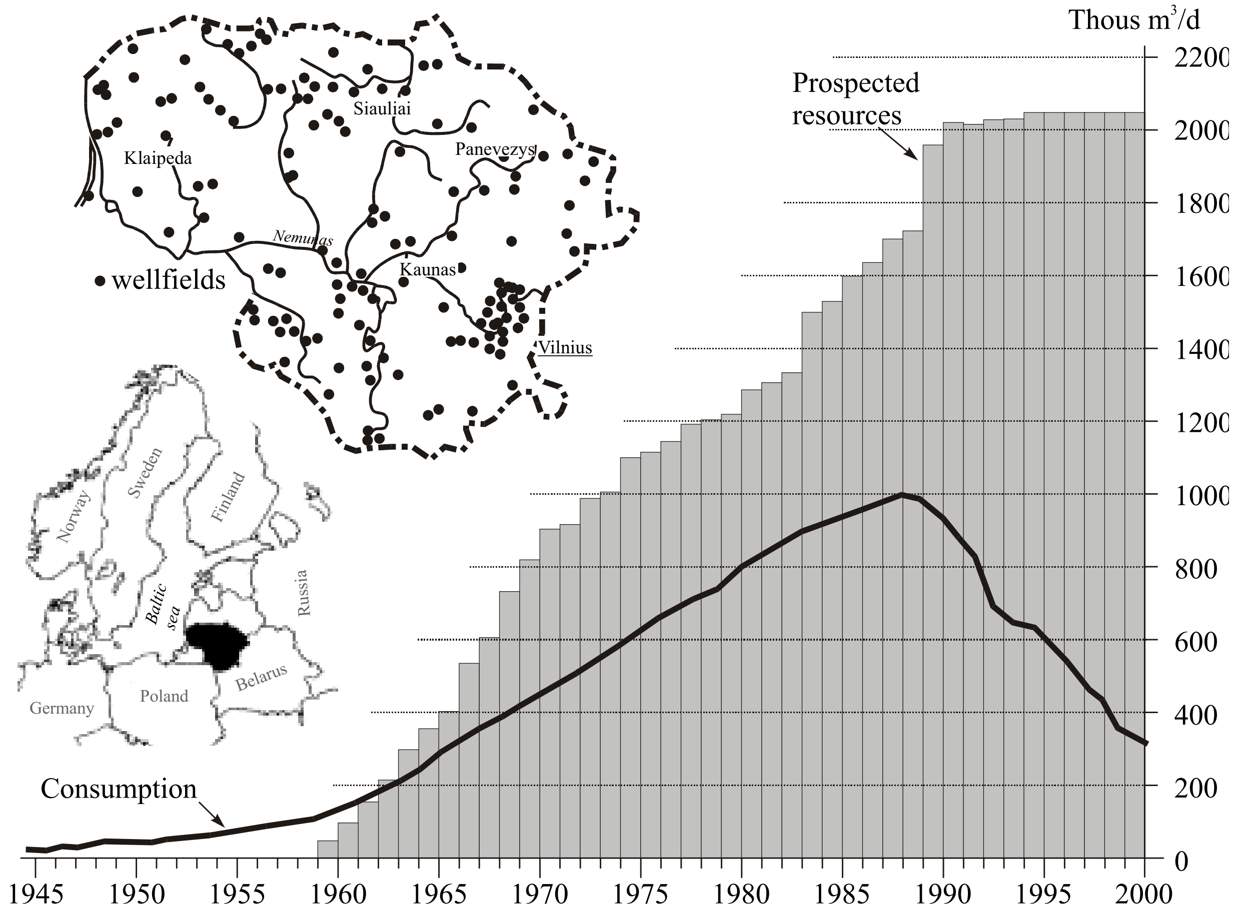

Fig. 1. Prospected and used fresh groundwater resources in Lithuania
1 pav. Lietuvos gėlo požeminio vandens išžvalgyti ištekliai ir jų sunaudojimas

ponents such as ammonium, iron, manganese, hydrogen sulphide, carbon dioxide, etc. and deteriorate some of the physical parameters of water. OM content in groundwater is not stable – it can grow due to OM accumulation or decrease because of OM degradation. Therefore OM investigations in fresh groundwater, especially long-term ones, are very important, since they reveal trends in groundwater quality changes.

Lithuania is one of a few European countries using only groundwater for centralised water supply and has accumulated a rather wide experience in this field. In order to provide urban population of Lithuania with drinking water, in 1959–1992 more than 100 groundwater wellfields were prospected, with the total safe yield nearly 2 million m^3/d. About 37% of these resources lie in river valley alluvium and 17% in the Quaternary intertill water-bearing sand and gravel, and about 46% occur in pre-Quaternary Cretaceous, Permian and Devonian water-bearing rocks. Such a large amount of prospected water resources can be explained by the Soviet prognoses that in 2000–2010 drinking water demand in Lithuania would reach 2.8 million m^3/d. However, after restoration of Lithuania's independence and changes in its economic structure, water price soared and its consumption made less than one third of the former level, reaching 0.3 million m^3/d (Fig. 1). Due to changes in water extraction its resources also undergo changes, at the same time OM content in groundwater increases, thus deteriorating its quality. The groundwater monitoring performed over the last decades enabled to accumulate numerous data on the variations in raw groundwater chemistry and OM content as well as to determine the regularities in the quality of drinking water supplied to urban population (both increased and decreased wellfield pumping rates); the results might be interesting for specialists from other countries.

FORMATION AND SPREADING OF ORGANIC MATTER IN FRESH GROUNDWATER

The possibilities for OM to enter groundwater and stay in water-bearing strata depend on the relations of groundwater with atmospheric precipitation, surface water and underlying aquifers, as well as on changes of these relations in the process of water extraction. In some cases, however, a significant role, sometimes crucial, belongs to the OM amount that has entered groundwater during formation of the aquifer rocks.

From the hydrogeological standpoint, Lithuania's area belongs to the Baltic Artesian Basin. Its upper part, the so-called active groundwater circulation zone, contains only fresh groundwater. According to the relations with atmospheric precipitation in particular and land surface in general, the aquifers of the above-mentioned zone are divided into shallow (water-table, unconfined) and interstratal (most often confined). In the riparian zones – river valleys, lake and sea coasts – the aquifers might have a close hydraulic connection with surface water. The near-surface interstratal aquifers are almost always hydraulically connected with the water-table or underlying confined aquifers. Taking into account the mentioned fresh groundwater occurrence conditions, all aquifers in the active groundwater exchange zone according to their interrelationships and relations with land surface and its water bodies can be divided into three types: *confined* (A), *semi-confined* (B) and *unconfined* (C) (Freeze and Cherry, 1979) (Fig. 2). In the conditions of each aquifer type, the processes of OM accumulation, distribution and degradation differ.

The *confined* type contains all pre-Qquaternary rock aquifers related mainly to Palaeogene, Cretaceous, Jurassic, Permian and Devonian formations. Rocks of these systems are not rich in OM. Exceptional cases are observed only for Jurassic and partly Lower Cretaceous deposits (Geology of Lithuania, 1994). Surface pollution cannot enter confined aquifers; therefore the main sources of OM concentration in groundwater are OM present in the aquifer rocks and metabolites of microbial activities. In separate cases, small amounts of mineral water containing higher levels of OM can reach the aquifers occurring in the lower part of the active exchange (aeration) zone through tectonic faults.

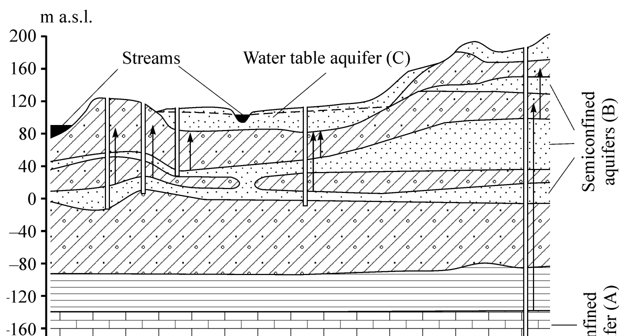

Fig. 2. Typical section of groundwater system in Lithuania.
1–2 – aquifers (*1* – sand, *2* – porous limestone); *3–4* – impermeable layers (*3* – aquifuge, *4* – aquitard); *5* – well and piezometric head
2 pav. Lietuvos požeminio vandens sistemų tipinis pjūvis: *1–2* – vandeningieji sluoksniai (*1* – smėlis, *2* – poringa klintis), *3–4* – pusiau laidūs ir nelaidūs sluoksniai (*3* – pusiau laidus sluoksnis, *4* – vandenspara), *5* – gręžinys ir pjezometrinis lygis

The *semi-confined* type includes all interstratal confined aquifers occurring in Quaternary glacial strata 50–100 m thick. All they are hydraulically connected with the water-table aquifer as well as with deeper-lying pre-Quaternary aquifers and actually are *semi-unconfined*. The bulk OM modifying OM content in this interstratal water comes from above. However, the Quaternary strata also contain rather high levels of OM. These are most often organic interglacial clayey formations.

The *unconfined* type embraces the water-table (unconfined) aquifer with water accumulated in the glacial till and fluvioglacial formations and river valley alluvium. In a narrow zone along the Baltic Sea coast, shallow groundwater occurs in the deposits of marine and aeolian origin, most often rich in OM, as in the case of alluvium (Geology of Lithuania, 1994). Aquifers of this type are not protected from surface pollution, besides, they usually are in a close hydraulic connection with surface water. From regional viewpoint, however, OM content in unconfined groundwater is modified most often by soils (agriculture) and only then by surface pollution.

So, there are two main groups of OM sources:

• external: (1) atmospheric and land surface pollution (including soil and fertilisers used in agriculture), (2) polluted surface water of rivers, canals, lakes, ponds and bogs;

• internal: (1) OM present in water-bearing and low-permeable rocks, (2) microorganism metabolites.

The first group is most typical of shallow water, especially unconfined, whereas the second group is important for interstratal semiconfined water isolated from the surface impact. OM content in a certain period of time and in a certain site of a groundwater system is not constant and depends on two different factors: 1) OM inflow or production by microorganisms, and 2) OM use in redox processes. Among the above-mentioned processes, however, often an equilibrium is formed; as a result, the OM content practically does not change.

The aquifer types differ with territory. Confined and semiconfined aquifers occur more often and are exploited for water supply to the northern part of

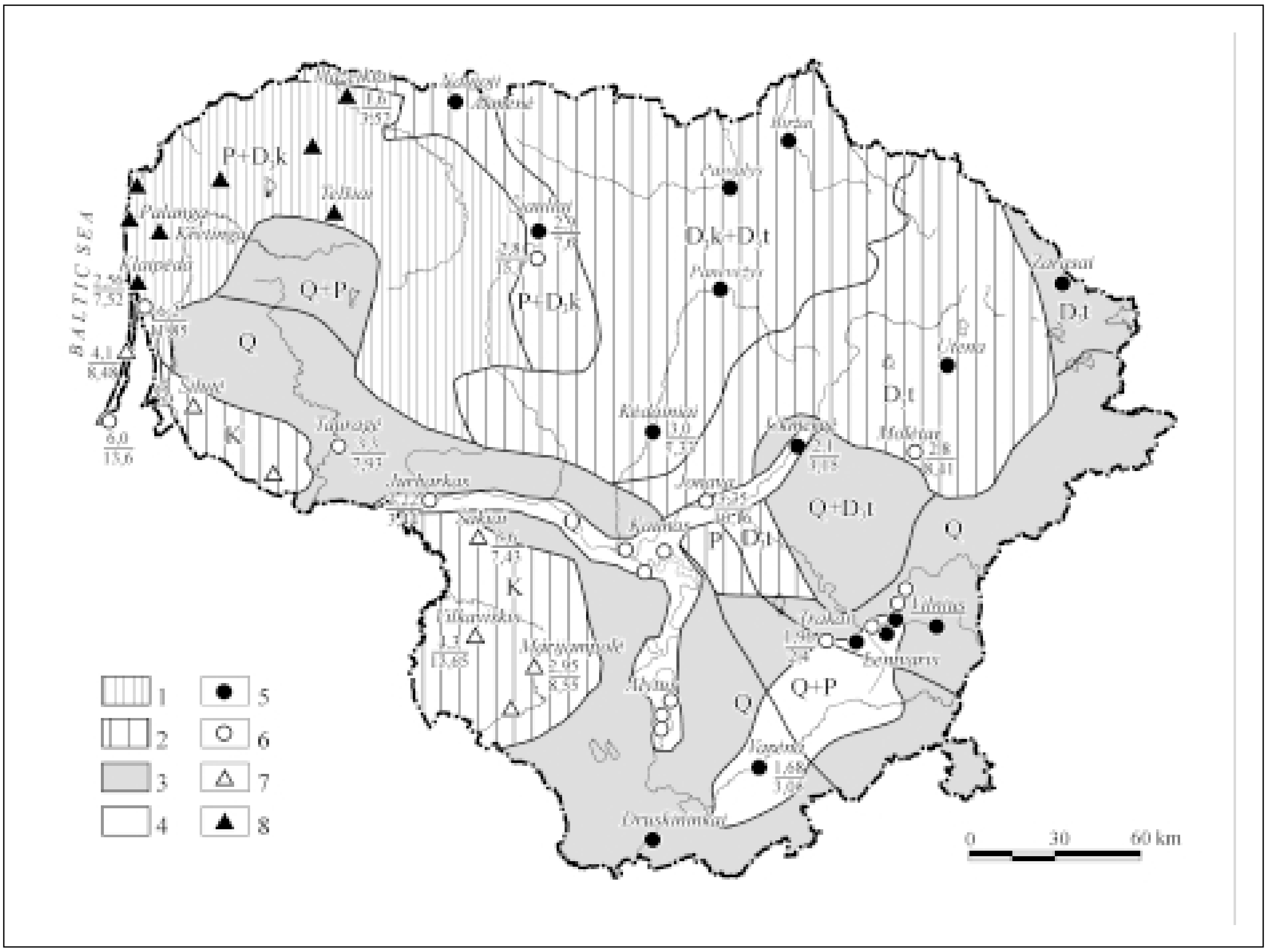

Fig. 3. Organic matter in groundwater of various Lithuanian urban wellfields: *1–4* – aquifer types (*1* – confined, *2* – semi-confined, *3* – semi-unconfined, *4* – unconfined; the geological index shows the main exploitable aquifer/complex, D_3t and D_3k are terrigenous and calcareous Devonian complexes, respectively); *5–8* – organic matter sources in the wellfields: *5–6* – external, *7–8* – internal (*5* – pollution, *6* – surface water, *7* – rocks, *8* – metabolism); fractions given at the wellfield signs express COD_{Mn} in nominator and COD_{Cr} in denominator, median value, in mg/l O_2

3 pav. Organinė medžiaga Lietuvos miestų vandenvietėse: *1–4* – vandeningieji sluoksniai (1 – uždari, *2* – pusiau uždari, *3* – pusiau atviri (spūdiniai-nespūdiniai), *4* – atviri (nespūdiniai)), *5–8* – organinės medžiagos šaltiniai *(5–6* – išoriniai (tarša ir paviršinis vanduo), *7–8* – vidiniai (uolienose esanti organinė medžiaga ir mikroorganizmų metabolizmo produktai)); skaičiai prie vandenviečių ženklo (medianinės vertės mg/l O_2): skaitiklyje – $ChDS_{Mn}$, vardiklyje – $ChDS_{Cr}$; svarbiausi vandeningieji horizontai ir kompleksai pažymėti geologiniais indeksais (D_3t ir D_3k – terigeninis ir karbonatinis vandeningieji kompleksai)

Lithuania, while unconfined or semi-unconfined types are more common in the southern and eastern parts (Fig. 3).

METHODOLOGY APPLIED FOR INVESTIGATION OF ORGANIC MATTER IN WELLFIELDS

The direct index of OM content in groundwater is organic carbon (C_{org}). However, in practice most often the summary OM index, *chemical oxygen demand* (COD) is used. It is determined in two ways: as permanganate oxidation (COD_{Mn}) and as bichromate oxidation (COD_{Cr}). There is the general opinion that the COD_{Mn} number shows easily high-oxidisable OM (fatty acids, most often acetoacetic or acetic acid) content in groundwater, while the COD_{Cr} number shows the content of low-oxidised OM (fats, proteins, hydrocarbons). Therefore, the values of both these indices and their ratio (COD_{Cr}/COD_{Mn}) enable to determine the type of OM (high or low degradable) prevailing in water, as well as its source. For instance, if the ratio is lower than 2.5, then humic organic compounds usually prevail in water (Лурье, 1984). High values of the ratio are indicative of groundwater pollution with low-oxidisable organic matter or of cases when OM is generated inside the aquifer, *e.g.*, the above-mentioned products of microbial metabolism (Крайнов, Швец, 1987).

In order to reveal OM content in groundwater used for centralised water supply for Lithuanian cities and towns, investigations have been carried out in 27 wellfields extracting water from Quaternary and pre-Quaternary aquifers (Fig. 4). To assess the general regularities, the retrospective data (from 1955–2002) on COD_{Mn} obtained in different laboratories have also been used; they were systematised by non-parametric statistical methods eliminating the hurricane values. Samples were taken from operating wells keeping to all technological requirements for water monitoring (Nielsen, 1991).

ORGANIC MATTER CONTENT IN GROUNDWATER OF OPERATING WELLFIELDS

Systematisation of the data by statistical methods showed that according to median values of OM content in groundwater the wellfields can be grouped into three types – those with a high, medium or low OM content, which reflect partly the above-mentioned confined, semiconfined and unconfined aquifers and groundwater formation conditions (see Fig. 4).

A more detailed analysis of these data shows a characteristic regularity: • at high COD_{Cr} values, the values of COD_{Mn}, as a rule several times lower than COD_{Cr}, are also rather high; • at low COD_{Cr} values, the values of COD_{Mn} are also low and close to

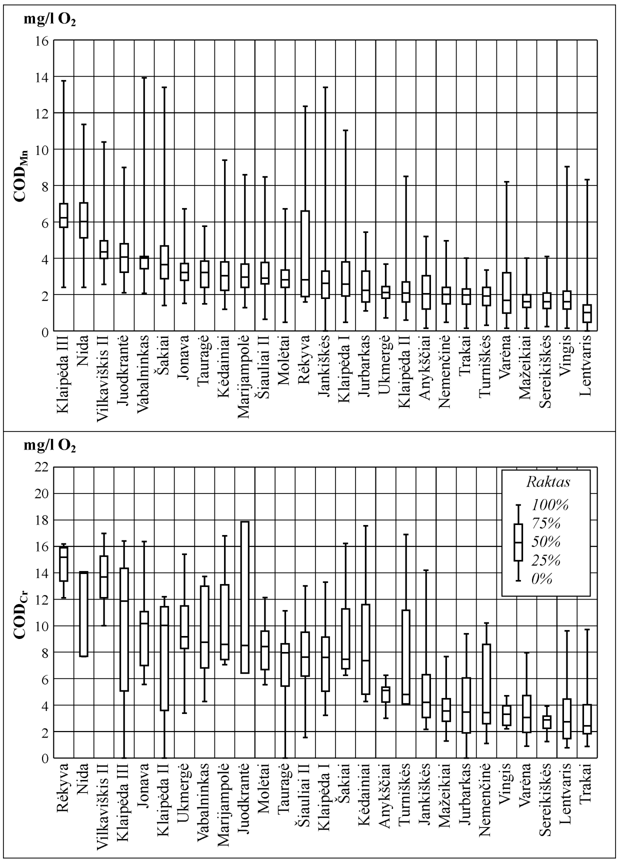

Fig. 4. Values of COD_{Mn} and COD_{Cr} in different wellfields (results of treatment by non-parametric statistics)
4 pav. $ChDS_{Mn}$ ir $ChDS_{Cr}$ vertės, gautos neparametrinės statistikos būdu įvairiose vandenvietėse

Table 1. **COD_{Mn} and COD_{Cr} values (mg/l O_2) in typical wellfields and the ratio of their median values**
1 lentelė. **$ChDS_{Mn}$ ir $ChDS_{Cr}$ vertės (mg/l O_2) ir jų santykis pagal medianines vertes**

Wellfield type, subtype	Typical wellfields	OM index	Number of analyses	Average	Median	Minimum	Maximum	COD_{Cr} / / COD_{Mn}
A	Klaipėda II	COD_{Mn}	361	2.39	2.08	0.6	8.5	4.8
		COD_{Cr}	11	8.10	10	0	12.2	
B	Vilkaviškis	COD_{Mn}	25	4.72	4.32	2.56	10.4	3.16
	II	COD_{Cr}	8	13.62	13.65	10	16.98	
B	Vilnius-	COD_{Mn}	368	1.74	1.6	0.24	4.1	1.8
	Sereikiškės	COD_{Cr}	15	2.67	2.86	1.25	3.93	
B	Rėkyva	COD_{Mn}	45	4.60	2.8	1.6	12.36	5.4
		COD_{Cr}	4	14.65	15.14	12.1	16.19	
B	Vilnius-	COD_{Mn}	423	1.85	1.6	0.16	9.04	2.1
	Vingis	COD_{Cr}	11	3.35	3.28	2.2	4.71	
C_1	Varėna	COD_{Mn}	113	2.27	1.68	0.16	8.2	1.8
		COD_{Cr}	13	3.76	3.05	0.9	7.96	
C_1	Juodkrantė	COD_{Mn}	52	4.37	4.05	2.1	9	2.1
		COD_{Cr}	3	10.92	8.48	6.42	17.86	
C_2	Klaipėda III	COD_{Mn}	233	6.37	6.2	2.4	13.76	1.8
		COD_{Cr}	8	9.87	11.85	0	16.4	
C_2	Vilnius -	COD_{Mn}	397	2.74	2.6	0	13.4	
	Jankiškės	COD_{Cr}	19	5.29	4.19	2.17	14.2	1.6

COD_{Cr} values. A conclusion follows that most often water contains one prevailing source of highly or low-oxidisable OM, and at the same time a prevailing hydrogeochemical process occurs in several stages: the aquifer accumulates first of all a certain amount of low-oxidisable OM which, depending on the conditions in the medium (oxygen content, temperature, microbial activities, etc.), is decomposed sooner or later into easier oxidisable forms. For instance, it is known that in the case of oil pollution compound aromatic hydrocarbons are oxidised only after microorganisms degrade them into their components (benzene ring is especially difficult to be degraded) (Fetter, 1993; Apello and Postma, 1993).

The ratio of the two above processes, OM accumulation and destruction, expressed as the COD_{Cr}/ /COD_{Mn} median value ratio enables to distinguish the prevailing value (Table 1).

The data listed in Table 1 show that the highest COD_{Cr}/COD_{Mn} values are within the range of high COD_{Cr} values. Hence, OM influx is higher than OM oxidation. There are, however, some exceptions related to peculiarities of some aquifers. So, Klaipėda III wellfield is notable for a low ratio of COD_{Cr}/ /COD_{Mn}, since COD_{Mn} here is very high due to high amounts of easily oxidisable humic and fulvic acids present in the marine sand of the water-table aquifer, hence in groundwater as well (Klimas and Bendoraitis, 1998). The situation is similar in other aquifers of unconfined type (C type), where the COD_{Cr}/ /COD_{Mn} ratios are low, since the summary values of both of them are also low (see Table 1, Vilnius–Jankiškės). This phenomenon is caused by the fact, that oxygen easily gets into unconfined aquifers and oxygen amount is sufficient for a rapid OM degradation to proceed.

These several examples show that in order to assess the COD values presenten in Fig. 4 and Table 1 and the factors forming them, the hydrogeological conditions and sources of OM influx into water should be analysed in more detail.

SOURCES OF ORGANIC MATTER ENTERING GROUNDWATER

The obtained data implied a simple conclusion: the COD values for separate wellfields are directly related to aquifer occurrence conditions. We shall discuss this deduction on several examples.

Under typical confined conditions (A), water of Klaipėda I and II wellfields is formed; here a Permian aquifer covered by thick Triassic clay compact strata is developed at a depth of 200–240 m. Therefore, only internal OM sources take place there (Klimas, 1994; 2001). One of the most important sources of water is that coming from the zone of saline water with OM content higher than in fresh groundwater. The median values of COD_{Cr} here reach 10 mg/l O_2 and exceed COD_{Mn} about 5 times. Since deeply occurring water contains nearly absolutely no oxygen, in the oxidation of OM entering the recharge zone oxygen from metal oxides and sulphate ions is involved. Therefore extracted water often contains hydrogen sulphide, and pyrite and mackinawite minerals are formed (Klimas, 2001).

B type wellfields operate semi-confined aquifers that are differently closed from above. The most tightly closed aquifer is operated by the Vilkaviškis waterworks. Water is extracted from Cretaceous rocks rich in OM. Moreover, the wellfield is installed in the drainage zone of regional mineral water. Therefore some amounts of OM could enter the water from the lower strata (Klimas, 1994). The median value of COD_{Cr} here is 13.65 mg/l O_2, *i.e.* 3 times higher than the values of COD_{Mn}. Oxygen content in groundwater here is very low (1–2 mg/l), therefore reduction of both iron and sulphates is intensive there.

Type B Vilnius-Sereikiškės and Vilnius-Vingis wellfield operate less confined aquifer; it pumps Quaternary deposit water occurring at a depth of 30–40 m and covered by a rather thin layer of morainic loam and loamy sand. The COD_{Cr} and COD_{Mn} values are not high (about 3 and 1.6 mg/l O_2, respectively). Since both wellfields are within the urbanised area, the main source of OM is urban pollution and partly surface water. The content of oxygen is rather high, therefore OM inflow and degradation processes are approximately in equilibrium. The situation is similar in the Rėkyva (Šiauliai) wellfield, where a Permian aquifer overlain by 40 m thick Quaternary rocks is operating. The surroundings of the wellfield, however, are highly bogged, and large amounts of OM enter the aquifer; here OM accumulation in groundwater is more intensive than degradation. Therefore both COD_{Cr} and COD_{Mn} differ greatly (15 and 2.8 mg/l O_2) (see Table 2).

Unconfined aquifers are divided into two subgroups, C_1 and C_2, according to relations with surface water. C_1 aquifers even pumped are not recharged by surface water. This subgroup comprises the Varėna wellfield operating a shallow aquifer water occurring in fluvioglacial deposits, and the Juodkrantė wellfield situated on the Baltic Sea coast and taking shallow water from marine sandy deposits. The Varėna wellfield is within the zone of urban pollution impact, and here water is polluted through the aeration zone. The median values of OM are low and close to Vilnius City B type wellfield values. The main source of OM in the Juodkrantė wellfield is water-bearing Holocene marine deposits.

Table 2. **Prevailing organic matter (OM) sources in typical wellfields**
2 lentelė. **Vyraujantys organinės medžiagos šaltiniai tipinėse vandenvietėse**

Wellfield type, subtypes	Typical wellfields	OM sources			
		Internal		External	
		OM in the rocks	metabolites	pollution from above	surface water
A	Klaipėda I, II	+	+		
B	Vilkaviškis,	+	+		
	Vilnius-Sereikiškės			+	
B	Šiauliai-Rėkyva,			+	+
	Vilnius-Vingis				
C_1	Varėna			+	
	Juodkrantė	+			
C_2	Vilnius-Jankiškės			+	+
	Klaipėda III				+

Therefore, as Table 2 data show, COD values can be significantly higher here.

Formation of two types of water in C_2 type wellfields is related mainly to surface water recharge during operation of wells. However, the second source is different for them. The Vilnius-Jankiškės wellfield receives OM partly through the aeration zone due to urban pollution, whereas the Klaipėda III wellfields accept OM partly from marine water-bearing sands (Table 2).

Factual OM contents in the wellfields of C type can be high or low, depending on whether or not OM supply intensity exceeds the degradation rate. For instance, for wellfields operating under intensive pollution conditions COD sometimes is low, because OM is intensively consumed in the reduction of iron and nitrates, and in the case of Vingis and Sereikiškės wellfields (B type) sulphate reduction is consumes OM.

TIME-RELATED VARIATIONS OF ORGANIC MATTER CONCENTRATIONS

Concentration of organic matter in groundwater and its chemistry undergo variations in time. Short-term changes related often to operation of certain production wells and long-term variations caused by changes in OM content in the recharging water, thus enhancing or suppressing OM accumulation in groundwater can be distinguished. These are complex processes; therefore their general features should be discussed taking into account data of wellfield water observation. Analysis of 53 wellfield COD_{Mn} trends showed a direct OM dependence on wellfield pumping rate in 31 cases. This dependence is most typical for riparian wellfields having a close hydraulic connection with surface water rich in OM (Fig. 5A). In this case, with the debit of inflow into the aquifer increasing, more surface water from the Neris River enters the aquifer and raises OM content. Later it decreases due to an intensive use of OM for reduction of nitrates getting in laterally, but of late years OM grew again, since the inflow of oxygen-rich water from the river had been reduced.

Nine of 53 wellfields show an adverse phenomenon – with decreasing pumping rates OM content in water increases. A typical example is the Klaipėda I wellfield (A type, Fig. 5B). As is mentioned above, this wellfield has not only an external but also an internal source of OM, and the role of the latter becomes even more important with a decrease in the debit.

During operation of many wellfields, sometimes abnormally high values of COD_{Mn} (and COD_{Cr}) oc-

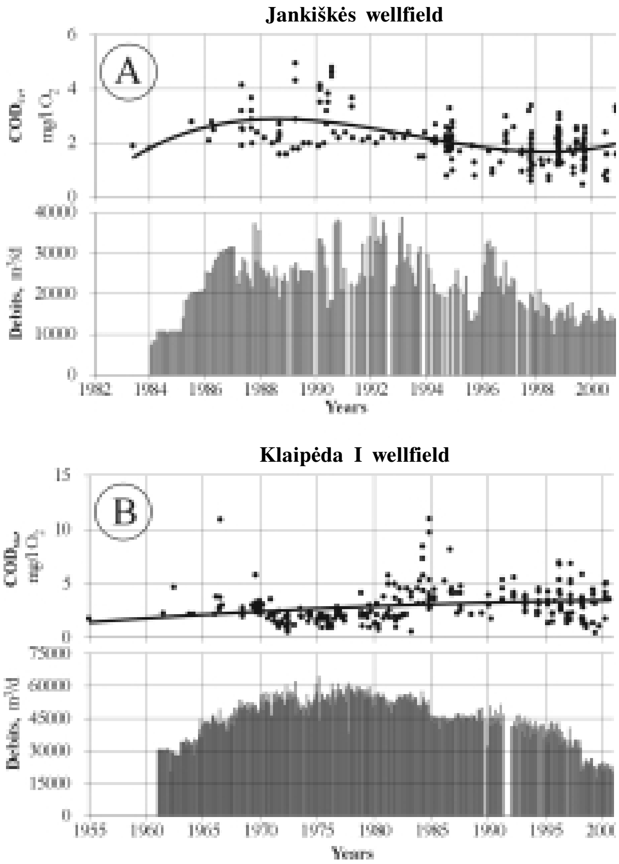

Fig. 5. COD_{Mn} dependence on pumping rate in typical wellfields
5 pav. $ChDS_{Mn}$ vertės priklausomybė nuo debito tipinėse vandenvietėse

cur. If they were accidental cases, they could be errors related to water sampling and laboratory problems. Such "little clouds" of COD_{Mn} values, however, are observed even in 24 of the 27 wellfields studied. Moreover, we can clearly see in Fig. 5 that periods of anomalous peaks of OM content in the wellfields are not accidental, since they were observed for a year or two, sometimes repeating, and sometimes for the last 3–5 or even more years. The reasons for their appearance are not clear. If they were seen, *e.g.*, only in unconfined aquifers (type wellfields), it would be probable that the OM peaks are caused by a sudden contribution from outside (pollution, surface water recharge). However, most often (in 15 of 24 wellfields) OM peaks are observed in confined aquifers (A type wellfields), such as Klaipėda I (see Fig. 5B). Therefore, they should be related first of all to the processes taking place in the aquifers under operation. Redox processes are most important, since OM is not only used as the main donor of electrons, but is also produced by microbes controlling these processes. Depending on the prevalence of the process (OM use or production), the OM indices – COD_{Mn} and COD_{Cr} values – decrease or grow. So, detailed investigations in the Klaipėda I wellfield revealed a cyclic character of sulphate reduction, when variations from minimum to maximum values take place not only in sulphate and sulphide concentrations, but also in OM and iron content (Klimas, 1994; 2001).

More and more facts appear in Lithuania that at lower debits of riparian wellfields and lower surface water inflow, reduction of trivalent iron into bivalent intensifies and hence more OM is consumed. The decreased COD_{Mn} values in such wellfields might be related to the above results. However, OM is consumed not only for trivalent iron reduction – at the same time OM content in water can grow due to accumulation of metabolites of iron bacteria activities (Diliūnas and Jurevičius, 1998). Therefore, a component of these processes, the COD_{Mn} value in water, can grow or decrease depending on the OM consumption/production ratio (Jankiškės wellfield, Fig. 5A).

CONCLUSIONS

• Changes in the summary OM content indices in the wellfields reflect their hydrogeological conditions, sources of groundwater safe-yield formation and variations during extraction, as well as complex hydro(bio)geochemical processes taking place in aquifers with OM participation.

• Generalisation of regularities in organic matter (OM) content changes in groundwater under production enables to assert that increase or decrease of COD_{Mn} values in unconfined riparian (subtype C_2 wellfields) and semi-confined multistratal aquifers (B type wellfields) is directly proportional to their pumping rates. However, some wellfields in riparian zones and some of those extracting water from several strata show the following regularity: with the debit decreasing, the COD_{Mn} values grow due to internal reasons – reduced water exchange, lower recharge of oxygen-rich water, increased activities of iron- and sulphate-reducing microbes. In such cases only the COD_{Mn} value is usually growing, while the COD_{Cr} values go down, because under conditions of lower water exchange the process of oxidation-resistant OM turning into high-oxidisable OM becomes impeded. However, high-oxidisable OM can be rapidly consumed by reduction of nitrates, iron and sulphates. Under such processes COD_{Mn} values also become significantly lower.

• That is the reason why OM affects drinking water quality not only directly but also indirectly, causing secondary changes in water chemical composition, first of all increasing the contents of iron (Fe), manganese (Mn), ammonium ion (NH_4^+) and hydrogen sulphide (H_2S) in groundwater used as drinking water.

• Investigations of variations of OM content and their impact on groundwater chemistry and quality are complicated, and these changes are best revealed by long-term monitoring. A constant decrease in water consumption during the last decade in Lithuania provided a rare opportunity to elucidate the regularities related to dependence of drinking water quality on redox processes taking place in aquifers with an active participation of organic matter.

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ORGANINĖS MEDŽIAGOS KONCENTRACIJOS POKYČIAI LIETUVOS GĖLO POŽEMINIO VANDENS TELKINIUOSE

S a n t r a u k a

Lietuvoje centralizuotai tiekiamas vien požeminis vanduo, kurio, atkūrus nepriklausomybę ir pasikeitus ekonominei sanklodai, sunaudojama beveik tris kartus mažiau. Dėl tos priežasties keičiasi požeminio vandens formavimosi sąlygos ir jo kokybė. Didelę reikšmę šio vandens kokybei turi organinė medžiaga, kuri svarbi dviem požiūriais: pirma, jos kiekis ir kai kurių organinių junginių koncentracija geriamajame vandenyje yra limituojama Europos Sąjungos Bendrąja vandens direktyva; antra, organinė medžiaga, oksidacijos procesui sunaudodama nemažą dalį deguonies, keičia vandeninguosiuose sluoksniuose hidrogeocheminę aplinką ir sudaro sąlygas oksidacijos ir redukcijos procesui. Dėl to vandenyje iki neleistinos koncentracijos gali padidėti amonio, geležies, mangano, sieros vandenilio bei kitų limituojamų komponentų kiekis, o vanduo gali tapti nebetinkamas gerti.

Straipsnyje, remiantis 27 tipinių vandenviečių ilgametės stebėsenos duomenimis, analizuojamos organinės medžiagos patekimo į požeminį vandenį sąlygos ir jos koncentracijos kaitos priklausomybė nuo vandenviečių eksploatacijos režimo.

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ИЗМЕНЕНИЕ КОНЦЕНТРАЦИИ ОРГАНИЧЕСКОГО ВЕЩЕСТВА В МЕСТОРОЖДЕНИЯХ ПРЕСНЫХ ПОДЗЕМНЫХ ВОД ЛИТВЫ

Р е з ю м е

В Литве для нужд централизованного водоснабжения используется только подземная вода. После восстановления независимости и изменения экономической ситуации потребление централизованно поставляемой питьевой воды снизилось почти в три раза. В связи с этим меняются условия формирования эксплуатационных запасов и качество извлекаемой воды. Большое значение для качества питьевой воды имеет содержащееся в ней органическое вещество, количество которого вызывает интерес с двух точек зрения: во-первых, концентрация некоторых органических соединений в питьевой воде лимитируется соответствующими стандартами; во-вторых, органическое вещество потребляет растворенный в подземной воде кислород и стимулирует окислительно-восстановительные реакции в водной среде. В связи с этим в питьевой воде концентрация некоторых компонентов (аммоний, железо, манган, сероводород и др.) может повыситься настолько, что вода становится частично или вовсе непригодной для потребления в качестве питьевой.

В статье на основе данных мониторинга 27 типовых водозаборов Литвы представлены результаты анализа условий попадания органического вещества в водоносные пласты и изменения его концентрации в зависимости от режима водоотбора.