Taylor & Francis
Taylor & Francis Group

JOURNAL OF ENVIRONMENTAL ENGINEERING AND LANDSCAPE MANAGEMENT
ISSN 1648–6897 print/ISSN 1822-4199 online
2012 Volume 20(2): 163–167
doi:10.3846/16486897.2012.674039

DETERMINATION OF ORGANIC MATTER BY UV ABSORPTION IN THE GROUND WATER

Ramunė Albrektienė[1], **Mindaugas Rimeika**[2], **Elena Zalieckienė**[3],
Valentinas Šaulys[4], **Alvydas Zagorskis**[5]
Vilnius Gediminas Technical University,
Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
E-mails: [1]*ramune.albrektiene@dok.vgtu.lt;* [2]*mindaugas.rimeika@vgtu.lt (corresponding author);*
[3]*elena.zalieckiene@vgtu.lt;* [4]*valentinas.saulys@vgtu.lt;* [5]*alvydas.zagorskis@vgtu.lt*

Submitted 27 Dec. 2011; accepted 06 Mar. 2012

Abstract. Organic matter in drinking water is determined by applying indirect determination methods used for quantitative measurements such as total organic carbon (TOC), chemical oxygen demand (COD), and biochemical oxygen demand (BOD). These analyses require expensive devices, harmful chemical reagents, and are time consuming. Standard water quality tests are inconvenient during start-up or reconstruction of drinking water treatment plants as samples need to be transported to a laboratory and no on-line measurements on plant performing efficiency are available. For practical purposes, less sophisticated and faster methods to determine organic matter are required. One of the methods could be ultraviolet absorption of water at 254 nm wavelength (UV_{254}). It is a technically simple and fast method for determining natural organic matter, requiring neither expensive measurement equipment nor chemical reagents. The present article aims at investigating the possibilities of practical applications of UV_{254} method to determine the concentration of natural organic matter in ground water. The research proved good correlation between TOC and UV_{254}, as well as between COD_{Mn} and UV_{254}. The outcomes of the research indicate that UV_{254} method can be successfully applied to determine natural organic matter concentrations in ground water.

Keywords: ground water, organic matter, ultraviolet absorption in water, UV, coagulation.

1. Introduction

Organic matter is a complex mixture of organic compounds found in ground water as well as in surface waters (Matilainen *et al.* 2011). In most cases, organic matter could be considered a natural organic matter (NOM) in ground water, as water is taken from deep wells where no artificial pollution is expected. NOM can be characterised by a range of components, from aliphatic to aromatic. NOM is divided into hydrophobic and hydrophillic compounds. The hydrophobic organic compounds are usually indicated as aromatic organic compounds, while the hydrophillic ones are mostly aliphatic with nitrogen molecules in their structure (Swietlik *et al.* 2004). The amount and characteristics of NOM in water depend on climate, geology and topography (Farbis *et al.* 2008; Wei *et al.* 2008).

Natural organic matter should be removed due to: 1) negative effect on drinking water quality (colour, taste, and odour); 2) increased doses of coagulant and disinfectant; 3) negative impact of disinfection by-products on human health (Singer 2006); 4) absorption of heavy metals by organic matters (Jacangelo *et al.* 1995, Matilainen *et al.* 2011). The most common technologies used for NOM removal are coagulation (Odergard *et al.* 2010), ion exchange (Boyer *et al.* 2008), membrane filtration (Kabsch-Korbutowicz *et al.* 2008; Revchuk *et al.* 2009; Yao *et al.* 2009) and various oxidation processes (Gallard *et al*. 2002; Huber *et al*. 2005).

Different methods are applied to determine NOM in water: spectroscopic methods (fluorescence, aromatic rings, -OH, NH_2 functional groups) (Baker *et al.* 2008, Hudson *et al.* 2008; Bieroza *et al.* 2009), UV-vis (aromatic rings, -OH, -COOH functional groups) (Korshin *et al.* 1999; Ates *et al.* 2007), chromatographic methods (separate different organic compounds) (Allpike *et al*. 2007; Korshin *et al.* 2009), mass spectrometric methods (structure of organic compounds) (Mawhinney *et al.* 2009).

Other methods are applied to detect organic matter. *Total organic carbon* (TOC) is considered to be the main indicator of organic matter in the drinking water. Organic carbon is oxidized to produce carbon dioxide by UV promoted or heat catalyzed chemical oxidation with a persulfate solution. The carrier gas delivers the combustion products to the cell of a non-dispersive gas analyzer, where carbon dioxide is detected. Inorganic carbon is removed by acidification and purging (EN 1484:2002). *Chemical oxygen demand* (COD_{Mn}) is a more common (but less accurate) way to determine the amount of organic matter in water. Potassium permanganate $KMnO_4$ is used for this purpose. Measured as the quantity of oxygen used for oxidation (mg O_2 L^{-1}), and is referred to as the Permanganate Index (EN ISO 8467). It is easier to oxidize biochemically stable colour organic compounds of humic nature rather than little transformed compounds produced during the bio process of the organisms (Walton *et al.* 1992).

The EU Council Directive 98/83/EB requires determination of the amount of organic compounds (acrylamide, benzene, 1,2-dichloretane, benzpyrene, polycyclic aromatic hydrocarbons, tetrachloretene and trichloretene, vinyl chloride) and total amount of organic matter in drinking water by applying indirect methods of organic matter determination: Total Organic Carbon (TOC) and Permanganate Index (PI).

Ultraviolet and visible absorption spectroscopy is the measurement of the attenuation of a beam of light after it passes through a sample or after reflection from a sample surface. This enables to determine the total amount of organic compounds in water by measuring the absorbance at a certain wavelength. The most common wavelengths for NOM measurements are from 220 nm to 280 nm. Absorbance at 254 nm is typical for measurements of aromatic compounds (Korshin *et al.* 2009).

The aim of the work was to compare methods of NOM measurement in raw and treated ground water. The methods used to determine NOM was TOC, COD_{Mn} and UV_{254}. The samples of ground water were collected from different locations. Removal of organic substances from ground water was carried out using the coagulants ($(Al_2(OH)_5)Cl$ and $FeCl_3$) in order to identify the impact of coagulation on correlation between TOC and UV_{254}, and COD_{Mn} and UV_{254}.

2. Materials and Methods

Water samples were collected from different places in Lithuania: wells in Juodkrantė, Preila, Nida (these wellfields are situated in Kuršių Nerija (Curonian Spit), at 15–30 m depth), 3^{rd} wellfield in Klaipėda city (its ground water has partial contact with the surface water), 6 wellfields in Vilnius (they are situated across the city, water was extracted from wells up to 100 m depth), and 7 wellfields in Ukmergė district (water was extracted from wells up to 200 m depth). During the period of 2009–2010, samples were taken twice from 17 wellfields. All water samples were taken directly from wells, without water treatment.

Before taking a sample, the water was allowed to flow from the tap for 5 min. The water samples were stored in plastic 5-litre containers, which were filled up to the top, in order to avoid contact with air. The water temperature and pH had to be measured immediately at the source, from which the sample was collected. The measurements had to be taken as soon as possible after the samples were collected (LST EN ISO 5667-3:2006; LST EN ISO 5667-5:2006/P:2007).

Total organic carbon was determined using "Shimadzu" carbon analyzer TOC-VCSH.

The Permanganate Index was determined using a water bath "Memmert WB 14", in which the temperature reaches from 96 °C to 98 °C during heating reaction; a 10 ml microburette "SCHOTT", with graduation value of 0.02 ml; and a meter unit "Thermo Labsystems 4540". 25 ml of sample water were put into test-tubes with 5 ml of 2 mol/*l* sulfuric acid, followed by a 10 min heating in a water bath. Then 5 ml of 2 mmol/*l* potassium permanganate were added, heated for another 10 min and supplemented with 5 ml of 5 mmol/*l* sodium oxalate. The process continued in a water bath until the colour faded and the solution cooled, followed by titration with 2 mmol/*l* permanganate to get a light pink colour (EN ISO 8467).

UV absorption was determined using a spectrophotometer "GENESYS 10UV/VIS", 10 mm optical cell, vacuum pump and 0.2 µm cellulose nitrate membrane filters. The water sample was membrane filtered and measured at 254 nm wavelength by a spectrophotometer.

Two coagulants, aluminium oxichloride ($Al_2(OH)_5Cl$) and ferric chloride ($FeCl_3$), were selected to carry out the coagulation process. Doses of coagulants equalled to 5 mg L^{-1}; 10 mg L^{-1}; 15 mg L^{-1}; 20 mg L^{-1}; 30 mg L^{-1} (doses were expressed as milligrams of pure aluminium or ferrous per 1 L of water). The coagulant was added into water samples and stirred, leaving then for 10 min to allow the coagulation process. It was followed by filtration through slow filtration paper filters. The filtered water was measured for TOC, COD_{Mn} and UV_{254}.

The quantitative results are presented as the arithmetic mean of five independent measurements (x±SD, $n = 5$). Significant differences ($p<0.05$) were removed from the result estimations and the measurements were analysed once again. The data from the experimental investigation were statistically calculated from the registered analyses. The concentration of substances (TOC, COD_{Mn} and UV_{254}) was measured 4 times in water samples. The average concentrations of substances, mentioned above, at the characteristic point, were also calculated. Applied analytical methods approved the precision rate below 10%.

3. Results

The research of ground water taken from different wellfields demonstrated TOC concentration range from 0.7 mg L^{-1} to 7 mg L^{-1}. According to the directive 98/83/EB, concentration of TOC is not regulated. The directive indicates the necessary monitoring of parametric concentration in order to avoid considerable non-specific alterations. Thus, concentration leaps have to be avoided while performing regular measurements of the parameter. The measurements of the parameter enable to state that the ground water supplied from the wells does not contain many organic substances, because of TOC concentration was between 6–7 mg L^{-1}. The investigation of correlation between the total organic carbon and UV absorption of drinking water at 254 nm wavelength was performed.

Fig. 1 presents linear correlation between TOC and UV_{254}, its mathematical expression being $TOC = 65.5 \cdot UV_{254} + 0.15$; $R^2 = 0.94$, which means that TOC and UV_{254} correlation is very strong as the coefficient of determination is very close to 1. The obtained results allow a clear assumption that if the high UV_{254} absorption are found in water, then high TOC concentration will be also expected. And from UV_{254} measurements the TOC concentration could be calculated in the ground water. Absorbance of light at 254 nm wavelength is most typical for the aromatic groups (Korshin *et al.* 2009), which means that aromatic organic compounds dominate in measured drinking water samples.

Fig. 2 indicates COD_{Mn} values in the tested ground waters. Maximum allowable rate for COD_{Mn} is 5 mg O_2 L^{-1}. Thus, neither of the water samples exceeds the maximum allowed level. Presented linear correlation between UV_{254} and COD_{Mn}, is expressed by equation $COD_{Mn} = 27.93$ $UV_{254} + 0.030$, and its coefficient of determination is equal to $R^2 = 0.88$. The obtained results show that UV_{254} and COD_{Mn} correlation is strong, although relation between UV_{254} and COD_{Mn} is weaker compared to the TOC and UV_{254}. Potassium permanganate is not a strong oxidiser therefore not all the organic compounds were oxidised in the samples, compared with TOC.

In order to clarify relationships and interchanges between determinations methods of NOM, coagulation process under laboratory conditions, were performed in order to remove organic substances from water. The results of the testing are presented in Fig. 3. Results shows that, when dose of the coagulant increases, the values of UV_{254} and COD_{Mn} are reduced. The relation between coagulant dose and COD_{Mn} is expressed by $COD_{Mn} = -0.05x+0.84$ and relation between coagulant dose and UV_{254} is expressed by $UV_{254}= -0.48x+22.4$.

The forth figure shows, how Permanganate Index and UV absorption in water at 254 nm wavelength change because of iron chloride coagulant.

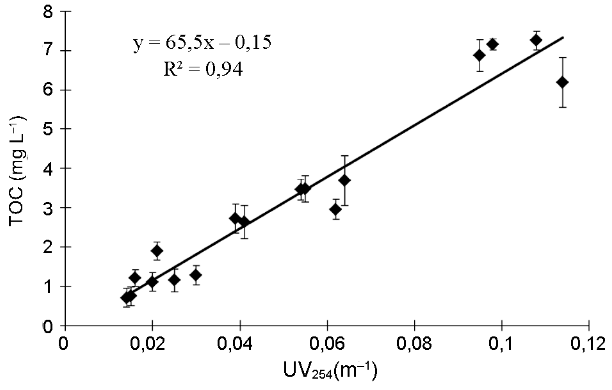

Fig. 1. TOC and UV_{254} correlation in the ground water (one point corresponds to one well)

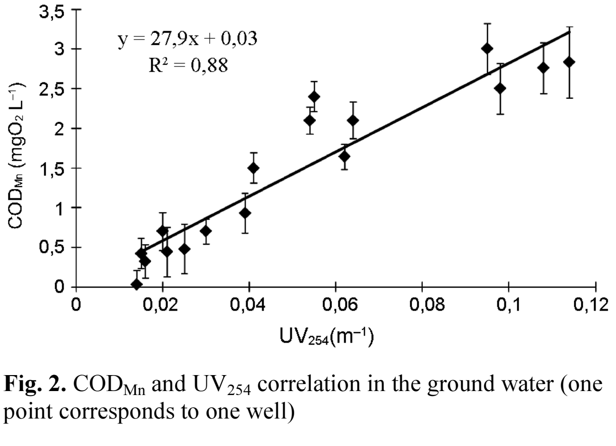

Fig. 2. COD_{Mn} and UV_{254} correlation in the ground water (one point corresponds to one well)

Fig. 4 shows that, when dose of the coagulant increases' the values of COD_{Mn} and UV_{254} are reduced. Relation between coagulant dose and COD_{Mn} is expressed by $COD_{Mn} = -0.84x+25{,}9$ and relation between coagulant dose and UV_{254} is expressed by $UV_{254}= -0.025x+088$.

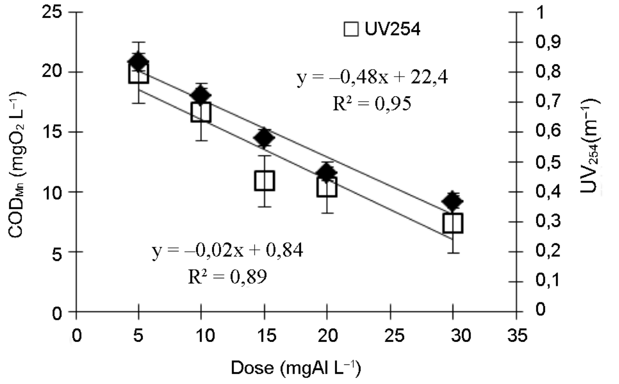

Fig. 3. Dependency of COD_{Mn} and UV_{254} on the dose of coagulant (aluminium oxichloride)

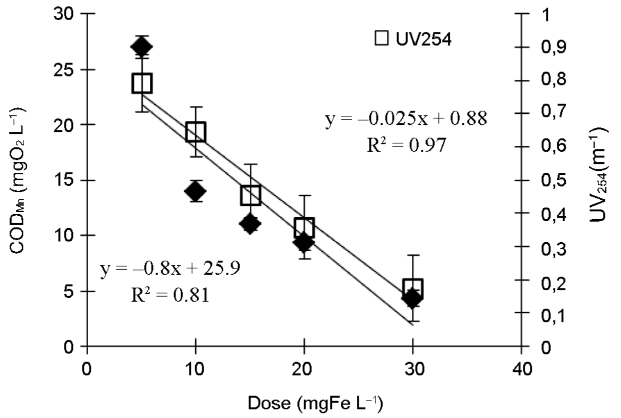

Fig. 4. Dependency of COD_{Mn} and UV_{254} on the dose of coagulant (iron chloride)

4. Discussion

Natural organic matter is commonly found in ground water. Quantity of natural organic matter was determined by applying indirect methods. NOM present in ground water is usually of natural origin. Despite its origin and the methods applied to remove NOM from drinking water, measurement of NOM concentration is required in all cases in order to determine water quality. Presently applied methods require expensive and sophisticated equipment and/or using chemical reagents. Quantitative measurements of NOM can only be performed in the laboratory because it is hardly possible to transport heavy and valuable devices or a large amount of them. During start-up of a water treatment plant, it is nearly impossible to bring all the necessary devices to the object. Even during the plant operation, the laboratory is often situated in a different city than the water treatment plant, which takes time and requires additional costs to transport samples. The method for determination of natural organic matter analysed in this article does not have the above mentioned drawbacks because only a standard spectrophotometer with over 254 nm wavelength can be used for measurement purposes. Another common way to remove NOM is by using reagents. Therefore, an important argument to apply this method, is minor difference detected in interdependence of different NOM measuring ways before and after the coagulation process. If the water is turbid, which often happens with surface water, turbidity measurements can be performed simultaneously.

The quality of ground and surface waters is different, thus, the dependencies presented in the article might not be the same in other places. Determination of UV absorption, however, enables their constant application. The research might be inaccurate for some cases, however, a several years' experience at different Lithuanian water sources indicated feasibility of UV absorption method. The amount of NOM in water and its removal in water treatment plants can be detected without applying comparative research on UV and other methods. In any case, the removal of organic matter causes decrease in turbidity and colour, and all these parameters are interrelated.

Moreover, determination of natural organic matter by UV absorption is more environmentally friendly and could be applied for more sustainable environment. Such NOM determination method requires no chemical reagents and less consumption of electricity compared to TOC determination. The analysed method can be easily and efficiently applied in practice.

5. Conclusions

1. Organic matters have different origins and a variety of analytical methods are applied for its quantity determination. (Organic matters concentrations in the ground water are determined experimentally, applying different determination methods, UV_{254}, TOC and COD_{Mn},, and comparing obtained results.)
2. The coefficient of determination between TOC and UV_{254} equals to 0.94, and between COD_{Mn} and UV_{254} equals to 0.88, therefore, the UV_{254} method can be successfully applied for determination of natural organic matter.
3. Similar UV_{254}, TOC and COD_{Mn} result interdependencies were obtained in the treated water, i.e. after removal of NOM with reagents. Change in NOM concentrations during coagulation process was similar, NOM concentrations decreased in proportion to all the measuring methods.
4. UV absorption method is fast, simple, and requires neither complicated equipment nor chemical reagents for quantification of natural organic matter. Thus, UV absorption can be applied in practice as an alternative for the standard methods that have been used so far.
5. Fast and reliable methods are required by water treatment practitioners dealing with efficiency assessment of water treatment technology by performing plant start-up and operation processes.

References

Allpike, B. P.; Heitz, A.; Joll, C. A.; Kagi, R. I. 2007. A new organic carbon detector for size exclusion chromatography, *J. Chromatography A* 1157: 472–476. http://dx.doi.org/10.1016/j.chroma.2007.05.073

Ates, N.; Kitis, M.; Yetis, U. 2007. Formation of chlorination by-products in waters with low SUVA correlations with SUVA and differential UV spectroscopy, *Water Research* 41(18): 4139-4148. http://dx.doi.org/10.1016/j.watres.2007.05.042

Baker, A.; Tipping, E.; Thacker, S.A.; Gondar, D. 2008. Relating dissolved organic matter fluorescence and functional properties, *Chemosphere* 73: 1765–1772. http://dx.doi.org/10.1016/j.chemosphere.2008.09.018

Bieroza, M.; Baker, A.; Bridgeman, J. 2009. Relating freshwater organic matter fluorescence to organic carbon removal efficiency in drinking water treatment, *Sci. Total Environ.* 407: 1765–1774. http://dx.doi.org/10.1016/j.scitotenv.2008.11.013

Boyer, T.; Singer, P.; Aiken, G. 2008. Removal of Dissolved Organic Matter by Anion Exchange: Effect of Dissolved Organic Matter Properties, *Environmental Science & Technology* 42 (19): 7431–7437. http://dx.doi.org/10.1021/es800714d

Fabris, R.; Chow, C. W. K.; Drikas, M.; Eikebrokk, B. 2008. Comparison of NOM character in selected Australian and Norwegian drinking waters, *Water Res.* 42: 4188–4196. http://dx.doi.org/10.1016/j.watres.2008.06.023

Gallard, H.; von Gunten, U. 2002. Chlorination of natural organic matter: kinetics of chlorination and of THM formation, *Water Res.* 36 (2002): 65–74. http://dx.doi.org/10.106/j.S0043-1354(01)00187-7

Huber, M. M.; Korhonen, S.; Ternes, T. A.; von Gunten, U. 2005. Oxidation of pharmaceuticals during water treatment with chlorine dioxide, *Water Res.* 39: 3607–3617. http://dx.doi.org/10.1016/j.watres.2005.05.040

Hudson, N.; Baker, A.; Ward, D.; Reynolds, D.M.; Brunsdon, C.; Carliell-Marquet, C.; Browning, S. 2008. Can fluorescence spectrometry be used as a surrogate for the biochemical oxygen demand (BOD) test in water quality assessment? An example from South West England, *Sci. Total Environ.* 391: 149–158. http://dx.doi.org/10.1016/j.scitotenv.2007.10.054

Jacangelo, J.; DeMarco, J.; Owen, D.; Randtke, S. 1995. Selected processes for removing NOM: an overview, *J. Am. Water Works Assoc.* 87 (1): 64–77.

Kabsch-Korbutowicz, M.; Biłyk, A.; Mołczan, M. 2005. The Effect of Feed Water Pretreatment on Ultrafiltration Membrane Performance, *Polish Journal of Environmental Studies* 15(5): 719–725.

Korshin, G. V.; Benjamin, M. M.; Li, C.-W. 1999. Use of differential spectroscopy to evaluate the structure and reactivity of humics, *Water Sci. Technol.* 40(9): 9–16. http://dx.doi.org/10.1016/S0273-1223(99)00634-4

Korshin, G.; Chow, Ch. W. K.; Fabris, R.; Drikas, M. 2009. Absorbance spectroscopy based examination of effects of coagulation on the reactivity of fractions of natural organic matter with varying apparent molecular weights, *Water Res.* 43 (2009): 1541–1548. http://dx.doi.org/10.1016/j.watres.2008.12.041

Matilainen, A.; Gjessing, E. T.; Lahtinen, T.; Hed, L.; Bhatnagar, A.; Sillanpää, M. 2011. An overview of the methods used in the characterisation of natural organic matter (NOM) in relation to drinking water treatment, *Chemosphere* 83(11): 1431–1442. http://dx.doi.org/10.1016/j.chemosphere.2011.01.018

Mawhinney, D. B.; Rosario-Ortiz, F. L.; Baik, S.; Vanderford, B. J.; Snyder, S. A. 2009. Characterization of fulvic acids by liquid chromatography-quadrupole time-offlight mass spectrometry, *J. Chromatogr. A* 1216: 1319–1324. http://dx.doi.org/10.1016/j.chroma.2008.12.068

Odegaard, H.; Osterhus, S.; Melin, E.; Eikebrokk, B. 2010. NOM removal technologies – Norwegian experiences, *Drink Water Engineering and Science* 3: 1–9. http://dx.doi.org/10.5194/dwes-3-1-2010

Revchuk, A.; Suffet, I. H. 2009 Ultrafiltration Separation of Aquatic Natural Organic Matter: Chemical Probes for Quality Assurance, *Water Res.* 43(15): 3685–3692. http://dx.doi.org/10.1016/j.watres.2009.05.029

Singer, P. C. 2006. DBPs in drinking water: additional scientific and policy considerations for public health protection, *J. Am. Water Works Assoc.* 98 (10): 73–80. http://dx.doi.org/10.1016/j.watres.2007.07.040

Swietlik, J.; Dabrowska, A.; Raczyk-Stanislawiak, U.; Nawrocki, J. 2004. Reactivity of natural organic matter fractions with chlorine dioxide and ozone, *Water Res.* 38: 547–558. http://dx.doi.org/10.1016/j.watres.2003.10.034

Walton, J.; Labine, P.; Reidies, A. 1992. The chemistry of permanganate in degradative oxidations, in *Chemical Oxidation, Technologies for the Nineties, Proceedings of the First International Symposium*, W. W. Eckenfelder, A. R. Bowers, and J. A. Roth (Eds.). Technomic Publishing Co., Inc., Lancaster, Penn.

Wei, Q.; Feng, C.; Wang, D.; Shi, B.; Zhang, L.; Wei, Q.; Tang, H. 2008. Seasonal variations of chemical and physical characteristics of dissolved organic matter and trihalomethane precursors in a reservoir: a case study, *J. Hazard. Mater.* 150: 257–264. http://dx.doi.org/10.1016/j.jhazmat.2007.04.096

Yao, P.; Choo, K. H.; Kim, M. H. 2009. A Hybridized Photocatalysis-Microfiltration System with Iron Oxide-Coated Membranes for the Removal of Natural Organic Matter in Water Treatment: Effects of Iron Oxide Layers and Colloids, *Water Res.* 43(17): 4238–4248. http://dx.doi.org/10.1016/j.watres.2009.06.010

ORGANINIŲ MEDŽIAGŲ POŽEMINIAME VANDENYJE NUSTATYMAS TAIKANT UV BANGŲ ABSORBCIJĄ

R. Albrektienė, M. Rimeika, E. Zalieckienė, V. Šaulys, A. Zagorskis

Santrauka

Organinės medžiagos požeminiame vandenyje nustatomos netiesioginiais kiekybiniais bendrosios organinės anglies (BOA), cheminio deguonies suvartojimo (ChDSMn) ir biocheminio deguonies suvartojimo (BDS) metodais. Šioms analitėms nustatyti būtini brangūs prietaisai, kenksmingi cheminiai reagentai, tyrimai ilgai trunka. Diegiant naujus geriamojo vandens gerinimo įrenginius ir atliekant įrenginių paleidimo, derinimo bei eksploatavimo proceso efektyvumo vertinimą, minėtuosius geriamojo vandens tyrimus nepatogu ir brangu atlikti, todėl šiais atvejais reikia paprastesnio ir greitesnio organinių medžiagų nustatymo metodo. 254 nm bangos ilgio (UV254) ultravioletinių spindulių absorbcija yra techniškai paprastas, spartus organinių junginių koncentracijų nustatymo metodas, jį taikant nebūtina brangi tyrimų įranga bei cheminiai reagentai. Šio darbo tikslas buvo ištirti UV254 metodo tinkamumą organinių junginių koncentracijoms nustatyti požeminiame vandenyje. Atlikus tyrimus apibrėžtos priklausomybės tarp BOA ir UV254 bei tarp ChDSMn ir UV254. Remiantis tyrimų rezultatais galima teigti, kad ultravioletinių spindulių absorbcijos metodas gali būti sėkmingai taikomas organinių junginių koncentracijoms požeminiame vandenyje nustatyti.

Reikšminiai žodžiai: požeminis vanduo, organinės medžiagos, ultravioletinių spindulių absorbcija, UV, koaguliacija.

Ramunė ALBREKTIENĖ. PhD student, Dept of Water Management, Vilnius Gediminas Technical University (VGTU). Master of Chemistry, Vilnius University (VU), 2005. Publications: 13 scientific publications. Research interests: drinking water quality, drinking water treatment.

Mindaugas RIMEIKA. Dr, Assoc. Prof., Dept of Water Management, Vilnius Gediminas Technical University (VGTU). Doctor of Technological Sciences (environmental engineering), VGTU, 2000. Publications: 2 educational books, over 30 scientific publications. Research interests: water network modeling, storm water management, biological water and wastewater treatment.

Elena ZALIECKIENĖ. Dr, Assoc. Prof., Dept of Chemistry and Bioengineering, Vilnius Gediminas Technical University (VGTU). Doctor of Natural Sciences, VU, 1978. Publications: 11 educational books, over 46 scientific publications. Research interests: analytic chemistry, analysis of natural objects.

Valentinas ŠAULYS. Prof. Dr, Head of Department of Hydraulics, Vilnius Gediminas Technical University (VGTU), Faculty of Environmental Engineering. The council member for water problems of Lithuanian science Academy. Publications: author of five books including educational and more than 190 research papers. Research interests: environmental engineering and landscape management, drainage system reliability and maintenance efficiency, processes of surface water seepage, water quality, water management policy.

Alvydas ZAGORSKIS. Dr, Assoc. Prof., Dept of Environmental Protection, Vilnius Gediminas Technical University (VGTU). Doctor of Technological Sciences (environmental engineering and landscape management), VGTU, 2009. Master of Science (environmental protection engineering), VGTU, 2005. Bachelor of Science (environmental engineering), VGTU, 2003. Publications: 26 scientific publications. Research interests: environmental protection, pollution prevention, biotechnology of air purification.