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1	Precise Estimation of Dodecylbenzenesulfonate (DBS) by
2	Using UV-Spectrometry in Aqueous Solution Containing
3	Dissolved Organic Matter (DOM) Extracted from Soil
4	
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17	
18	Running Title: Estimation of DBS from DBS-DOM complex solutions
19	

20 Abstract

Precise estimation of sodium dodecylbenzenesulfonate (DBS) is essential for 21 22 understanding its adsorption in soils, transport, toxicity, fate, and its application in the remediation of contaminated soil and groundwater. DBS can be easily identified by its 23 conjugated double bond systems of benzene ring under the ultraviolet (UV) spectrum 24 25 of the spectrophotometer. However, benzene group components of dissolved organic 26 matter (DOM) also absorb light in the UV spectrum, and this effect is responsible for 27 the excess quantities of DBS that are falsely measured by spectrophotometers. This 28 study was conducted to propose a method for accurately measuring the DBS concentration of a solution containing DOM. To elucidate the influence of DOM during 29 the UV-spectroscopic measurement of DBS in an aqueous solution, 222.5 nm UV and 30 400 nm UV-vis spectra were measured. The DOM was extracted from a highly humic 31 non-allophanic volcanic ash (Andosol) soil by using 1 mmol NaCl/L and 100 mmol 32 33 NaCl/L solutions as the extractors. The absorbances at both 222.5 nm and 400 nm increased in proportion to the increase in the DOM concentration. The relationship 34 35 between the absorbances at the two different wavelengths could be expressed as a linear 36 relationship. On the other hand, the absorbance at 400 nm did not increase with the increase in the DBS concentration, while the absorbance at 222.5 nm increased with the 37 increase in the DOM concentration. Therefore, we inferred that the influence of DOM 38 on the absorbance value of the DBS-DOM complex solution at 222.5 nm could be 39 eliminated by using the linear relationship between the two different absorbances of the 40 41 DBS-free DOM solution. This method makes it possible to easily measure the DBS concentration of a solution from soil water, streams, or industrial effluents containing 42 43 DOM, without using reagents.

45	Keywords: Andosol, Dissolved organic matter, dodecylbenzenesulfonate, humic soil,
46	UV-vis, UV Spectrometry.
47	
48	Highlights
49	• Dodecylbenzenesulfonate in a solution is overestimated in the presence of dissolved

- 51 Dodecylbenzenesulfonate becomes precisely detectable using 222.5 nm and 400 nm 52 spectrophotometry.
- 53 Our proposed method is simple, rapid, efficient, and requires no special reagent or recurring cost. 54
- This method can be used for precise DBS estimation in soil water, streams, or 55 industrial effluents. 56
- 57

58 1. Introduction

Nowadays, environmental studies have been largely focused on the presence of 59 surfactants in the soil-water system (Cao et al., 2008; Rodriguez-Escales et al., 2012). 60 Among all the anionic surfactants, dodecyl sulphate and dodecylbenzenesulfonate 61 62 (DBS) are the ingredients of most currently available cleaning agents and other commonly used commercial products (Myers, 2005; Texter, 1999; Nollet, 2007; Zoller, 63 64 2005). Sodium DBS is widely used in industries and households around the globe for the same purpose (Fachini et al., 2007; He et al., 1991; Inoue et al., 1978). However, 65 DBS is also one of the most common organic pollutants found in nearly every 66 environmental component (McAvoy et al., 1994). It is considered as a major soil 67 contaminant and is often present in sewage sludge, solid waste, industrial waste, and 68 69 wastewater (Sablayrolles et al., 2009).

70 The discharge of DBS into the environment causes it to interact and be adsorbed onto the soil (Ahmed & Ishiguro, 2015). When these compounds are adsorbed onto 71 72 soils, they appear to degrade slowly (Tabor & Barber, 1996), and are moderately toxic to invertebrates and numerous higher plants (Kloepper-Sams et al., 1996). In fact in the 73 long term, DBS is harmful to aquatic organisms, animals, soils, and plants (Sablayrolles 74 75 et al., 2009). The use of high amounts of untreated surfactant-contaminated irrigation 76 water is widespread in rural and undeveloped areas. The surfactants can alter soil 77 physicochemical and biological properties (Dai et al., 2001). Anionic surfactants such 78 as DBS are sometimes used as cleaning agents of contaminated soils and groundwater (Mulligan et al., 2001). Therefore, the precise estimation of DBS is essential for 79 understanding its adsorption in soils, transport, toxicity, fate, and its application in the 80 81 remediation of contaminated soils and groundwater.

Dissolved organic matter (DOM) is a major component of organic carbon 82 83 (Williams et al., 2016) that influences the distribution, mobilization, and degradation of soil pollutants, such as organic toxicants, at the soil- soil solution interface (Chen et 84 al., 2010; Huo et al., 2008; Jiang et al., 2008; Ma et al., 2001; Song et al., 2007). 85 86 Dissolved organic matter in natural environments consists of diverse types of organic molecules, most of which do not have easily recognizable chemical structure. Besides 87 the non-humic part of the DOM, the maximum portion (50% to 70%) usually covers 88 the humic substances which comprise a general class of biogenic, heterogeneous, and 89 refractory organic compounds, occurring in all terrestrial and aquatic environments 90 91 (Karavanova, 2013; Pettit, 2008; Thurman, 1985; Wetzel, 1983). Humic substances are significant in hydrochemistry and aquatic toxicology because they can bind both metals 92 and hydrophobic organic pollutants such as DBS (Alberts & Giesy, 1983; Carter & 93 Suffet, 1982; Gjessing & Berglind, 1981; Hassett & Milicic, 1985; Ishiguro & Koopal, 94

2016; McCarthy & Jimenez, 1985; Servos & Muir, 1989). Usually, humic substances 95 are divided into three different fractions, namely, humic acids, fulvic acids, and humins 96 (Fenchel et al., 2012; Kumada, 1965; Pettit, 2008). Humic acids are dark brown to black 97 in colour, fulvic acids are light yellow to yellow-brown in colour, and humins are black 98 in colour (Stevenson, 1995). Therefore, DOM has a dark yellowish-brown to a black 99 colour appearance in aqueous solution, depending on the quantity and ratio of the 100 101 different organic portions dissolved in solution (Zhao et al., 2008). It is assumed that the high turbidity of the soil solution is caused by the presence of the DOM, especially 102 103 when the humic substance is present at a considerably higher quantity. The DOM concentration increases with higher pH, lower electrolyte concentration, and higher 104 anionic surfactant concentration when a highly humic soil was shaken with the solution 105 (Ahmed et al., 2012). 106

Dodecylbenzenesulfonate concentration in soil solution is sometimes measured by 107 108 the absorbance of ultraviolet (UV) wavelength with a UV-spectrophotometer (Torn et al., 2003), such as at 222.5 nm, because it allows the detection of the conjugated double 109 bond systems of benzene rings (Nakahara, 2002; Ni et al., 2018). This method is very 110 111 simple and useful, as the solution could be directly measured without any reagents. However, when DOM is not negligibly included in the solution, DBS concentration 112 must be adjusted, excluding the influence of DOM because the absorbance at the UV 113 spectrum increases with the influence of unsaturated compounds, which includes the 114 benzene ring in the DOM (Zhang et al. 2019). Generally, batch DBS adsorption or 115 desorption experiment of highly humic soils that were previously treated with 116 electrolytes and DBS would display such confusing results under UV-spectroscopy. To 117 eliminate such confusion regarding DBS concentration in the aqueous solution 118 containing a substantial quantity of DOM, it is necessary to precisely measure the 119

influence of the DOM portion in the solution. Both DBS and DOM absorb the
electromagnetic radiation that exhibits a wavelength of 222.5 nm. However, DOM also
absorbs visible light with a wavelength of 400 nm, while DBS does not. It is believed
that the influence of DOM can be eliminated by using this characteristic.

The aim of this study was to propose a method for the precise estimation of DBS concentration in solutions containing different concentrations of DOM, taking into account the influence of DOM using UV-spectrophotometry. In order to eliminate the influence of DOM, the absorbance at the 400 nm visible light spectrum was measured together with that at the 222.5 nm UV spectrum.

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130 2. Materials and Methods

131 2.1. Extracted dissolved organic matter solution

To prepare the extracted DOM solution for this study, a highly humic non-132 allophanic Andosol from the A-horizon (Daisen pasture, Tottori Prefecture, Japan) was 133 used to extract the organic matter. Generally, Andosols have a thick dark A-horizon, 134 with abundant organic matter (Schaetzl & Anderson, 2015). The carbon content of the 135 136 soil was 13.8%, and the soil physico-chemical characteristics were reported by Ahmed and Ishiguro (2015). The DOM was extracted as dissolved solid (DS) with sodium 137 chloride (NaCl) solution, a method that is almost similar to the salt extraction method 138 of DOM as described by Kalbitz et al. (2007). The extraction was carried out with 1 139 mmol NaCl/L at pH 6.0 and 100 mmol NaCl/L at pH 5.0, using a soil and electrolyte 140 141 solution ratio of 1:15 (w/v, dry weight basis) in an electro-mechanical reciprocal shaker at 180 rpm at 25 °C. The pH of the solution was set to a value close to the natural pH 142 at the concentration of the electrolyte solution. Different durations of shaking, namely, 143 1 h, 6 h, 24 h, and 48 h were applied to different centrifuge tubes to produce DOM 144

solutions with different concentrations of DS containing DOM. After that, the suspensions were centrifuged at 8000 rpm for 10 min at 25 °C, and, finally, the supernatants were filtered through a No. 6 filter paper and stored in separate plastic bottles.

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150 2.2. Reagents
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151 The principal reagent used in this study was linear sodium DBS, which is an (Holmberg. 2019) 152 anionic surfactant having the chemical composition 153 C₁₂H₂₅C₆H₄SO₃Na and molecular weight of 348.48 g/mol, purchased from Fujifilm Wako Pure Chemical Corporation, Osaka, Japan in white crystalline powder form, with 154 a purity of approximately 99+%. Sodium chloride was also purchased from Fujifilm 155 Wako Pure Chemical Corporation, Osaka, Japan, with a purity of 98+%. 156

157

158 2.3. Dodecylbenzenesulfonate–dissolved organic matter complex solution

To examine the influence of DOM on the DBS solution for the detection of DBS 159 concentration using UV-spectrophotometer, three different concentrations of DBS 160 solutions were prepared. Triplicates of 0, 50, and 500 µmol DBS/L solutions were 161 prepared using the previously extracted DOM solution as a solvent, with eight different 162 concentrations of DS and 1 mmol NaCl/L at pH 6.0 or 100 mmol NaCl/L at pH 5.0. 163 DOM-free DBS solutions were also prepared to obtain the DBS standard curve. After 164 the addition of DBS to the DOM solution, the solution was referred to as the DBS-165 DOM complex solution, wherein the absorbance characteristics of DBS and DOM 166 overlapped. 167

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169 2.4. Measurement of absorbance at 222.5 nm and 400 nm

A wavelength of 400 nm is the lowermost wavelength of visible light (400 nm 170 to 780 nm) (Lambert et al., 2014). Given that 400 nm is the visible light wavelength at 171 172 which the absorbance of humic acid is highest (Kumada, 1965; Sorouradin et al., 1993), this wavelength was adopted in the study. One millilitre of the formerly prepared DBS 173 solutions, from every triplicate, was diluted ten times with deionized water, and the 174 absorbance at 400 nm UV-vis light spectrum and 222.5 nm UV light spectrum were 175 176 measured using the Shimadzu UV-1208 spectrophotometer. Absorbances both at 222.5 nm and 400 nm for the 10 times-diluted DOM solution without DBS was also recorded 177 178 along with the DBS standard solutions' calibration curve from the UVspectrophotometer. Since the original DBS-DOM complex solutions were diluted 10 179 times before spectroscopic measurements, the NaCl concentrations were 0, 0.1, and 10 180 mmol/L and the DBS concentrations were 0, 5, and 50 µmol/L. 181

182

183 2.5 Dissolved solids concentration

As the DS concentration was supposed to be in proportion to the DOM concentration, the DS concentration was measured as the index of the DOM concentration. The DS concentration of the DOM solution which did not include DBS was measured. After 200 mL of the DOM solution was oven-dried at 60 °C for 4 d, the dry weight was measured, and the DS concentration was calculated.

189

190 **3. Results**

191 *3.1. Influence of dissolved solids and DBS on the absorbance at 222.5 nm*

The influence of DS concentrations on the absorbance at 222.5 nm is shown in Fig. 1 and Table 1. The results indicated a strong correlation between the 222.5 nm absorbance and the DS concentration. The absorbance at 222.5 nm increased in proportion to the DS concentration for both the 0.1 mmol NaCl/L and 10 mmol NaCl/Lsolutions (Fig. 1).

The absorbance of the DBS–DOM complex solution at 222.5 nm is also plotted in Fig. 1. Similar to the result of DBS-free solution, a strong positive linear relationship at each DBS concentration was found between the absorbance values in the 222.5 nm spectrum and the DS concentration (Table 1). The slopes of the linear lines of the NaCl solutions were similar to those obtained with the different concentrations of DBS solutions; these slope values ranged between 0.021 and 0.022 for 0.1 mmol NaCl/L solutions and went 0.0029 to 0.0033 for 10 mmol NaCl/L solutions (**Table 1**).

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205 3.2. Influence of dissolved solids and DBS on the absorbance at 400 nm

The influences of DS and DBS concentration on absorbance at 400 nm are shown in Fig. 2. The coefficients of determination (R²) for the 0.1 mmol and 10 mmol NaCl/L solution indicated a strong correlation between the 400 nm absorbance and the DS concentration (Table 1); this absorbance is considered to correspond to the visible DS. Even if the DBS concentration changed, the absorbance remained constant with constant DS concentration. Therefore, the DBS had no effect on the absorbance at 400 nm, as shown in Fig. 2.

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214 *3.3. Relationship between absorbances of the two spectra*

The absorbances of the DBS–DOM solutions at 222.5 nm and 400 nm spectra are plotted in Fig. 3. The linear regression lines for the values of the DBS-DOM solution with the same DBS concentration are shown in the figure. A strong linear relationship was observed (Table 1) because the DS concentration was in proportion to the absorbances at both 222.5 nm (Fig. 1) and 400 nm (Fig. 2). The absorbance at 222.5
nm increased with an increase in absorbance at 400 nm.

221 The slopes of the linear lines were almost similar among the different concentrations of DBS, and the two NaCl/L solutions (Table 1). For the solution containing 0.1 mmol 222 NaCl/L and 5 µmol DBS/L, the average increase in the absorbance at 222.5 nm from 223 224 that at 0 µmol DBS/L was 0.07, and the standard deviation was 0.005. For the solution 225 containing 0.1 mmol NaCl/L and 50 µmol DBS/L, the average increase in the absorbance at 222.5 nm was 0.62, and the standard deviation was 0.02. Similarly, the 226 227 average increase was 0.06 and 0.62, and the standard deviation was 0.002 and 0.008 for the 5 µmol and 50 µmol DBS/L solutions, respectively, in 10 mmol NaCl/L solution. 228 The increase in the absorbance at 222.5 nm were almost the same for the solutions with 229 the same DBS concentration, even though the concentration of the NaCl solution 230 differed. 231

232

3.4. Elimination of the influence of the dissolved solids on the measurement of DBSconcentration

Dodecylbenzenesulfonate had no effect on the absorbance at 400 nm, as shown in Fig. 2. Contrarily, DS concentration showed a strong positive linear relationship with the values in the 400 nm spectra (Fig. 2). It was also found that the 222.5 nm UVspectrum could detect both DBS and DS in the aqueous solution. Therefore, to overcome and eliminate the aforementioned effects of DS in the aqueous solution during the UV-spectroscopic analysis of DBS, a systematic method could be established using the absorbance values at 222.5 nm and 400 nm.

The two measured spectra showed linear positive increases with an increase in theDS concentration. Therefore, a linear regression model with the absorbance data of



$$255 \qquad C=ay(DBS)+b \tag{2}$$

where *C* is the DBS concentration, y(DBS) is the 222.5 nm absorbance of the DOMfree DBS solution, and a and b are the constants. The 222.5 nm absorbance for the DBS-DOM complex solution, y(DBS+DOM), can be written as such because the absorbance is divided into the absorbance value of the DBS, y(DBS), and that of DS, y(DOM), as shown in Fig. 4.

261 v(DB)

$$S+DOM) = y(DBS) + y(DOM).$$
(3)

262 On the other hand, the following equation is satisfied because DBS does not influence263 the 400 nm absorbance:

264
$$x(DBS+DOM) = x(DOM)$$
 (4)

where x(DBS+DOM) is the 400 nm absorbance of the DBS–DOM complex solution.

From equations (1) to (4), we get the DBS concentration of DBS–DOM solution, C,

267
$$C = a[y(DBS+DOM)-\{Ax(DBS+DOM)+B\}]+b$$
 (5)

When y(DBS+DOM) and x(DBS+DOM) are measured and the constants, a, b, A, and B are obtained from the standard curves, we can obtain the DBS concentration of DBS-DOM solution by eliminating the influence of DS.

The relationship between the actual and measured DBS concentrations of the DBS– DOM complex solution without elimination of DS influence is shown in Fig. 5. The actual DBS concentration was obtained using appropriately diluted DBS. The measured DBS concentration, shown in Fig. 5, was obtained by directly using the measured 222.5 nm absorbance, *y*(DBS+DOM), in Eq. 2 of the DBS standard curve, as follows:

276 C = ay(DBS + DOM) + b. (6)

The DBS standard curve is also added in the figure. Due to the influence of DS, the measured DBS concentration of the DBS–DOM solution was higher (for both electrolyte conditions) than that of the DOM-free DBS standard solution.

The DBS concentration of the DBS–DOM solution was calculated using Eq. 5. The values of the constants were a = 79.78, b = 1.82, A = 5.92, and B = 0.072 for the 0.1 mmol NaCl/L solution and a = 80.73, b = 4.88, A = 8.36, and B = 0.066 for the 10 mmol NaCl/L solution. The calculated DBS concentration values, which were almost on the DBS standard curves, are shown in Fig. 6. The effect of DS on the 222.5 nm absorbance was successfully eliminated. The differences in results before and after the DS elimination are evident in Fig. 5.

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3.5. Influence of the sodium chloride concentration of the dissolved organic matterextracted solution on the absorbances

As illustrated in Figs. 1 and 2, the DS concentrations decreased when extracted with higher concentrations of electrolyte solution, (100 mmol NaCl/L) even though the same extraction procedure was followed. The correlations and the slopes of the linear regression lines between the DS concentration and absorbances at 222.5 nm and 400
nm spectra for 0.1 mmol NaCl/L and 10 mmol NaCl/L conditions are given in Table 1.
The coefficients of determination (R²) between DS concentration and absorbance at
222.5 nm and 400 nm for the 0.1 mmol NaCl/L solution were higher than for 10 mmol
NaCl/L solution (Figs. 1 and 2). A similar trend was observed for correlations between
the absorbances at 222.5 nm and 400 nm spectra.

As shown in Fig. 1 and Table 1, the slope of the DS concentration versus the 222.5 nm

absorbance of the 0.1 mmol NaCl/L solution was higher than for the 10 mmol NaCl/L

solution. The slope of the DS concentration versus the 400 nm absorbance also showed

a similar trend. However, the slope of the linear relationship between 400 nm and 222.5

303 nm absorbance in the 0.1 mmol NaCl/L solution was different from that for the 10 mmol

NaCl/L solution (Fig. 3, Table 1), and the difference was considerably lower.

305

306 **4. Discussion**

We successfully presented a method for the measurement of DBS concentration in the DBS–DOM complex solution by eliminating the effect of DS (Figs. 5 and 6). The exact DBS concentration in the DBS–DOM complex solution was obtained by using its 400 nm absorbance values (Eq. (5)) and the corresponding DOM standard curve (Eq. 1), as well as the 222.5 nm absorbance values of the DBS–DOM complex solution (Eq. 5) and the corresponding DBS standard curve (Eq. 2).

A strong linear correlation between the 222.5 nm absorbance and the DS concentration was observed (**Fig. 1; Table 1**). Although the concentration of DS is not equal to that of the DOM, the DOM concentration is supposed to linearly correlate with the DS concentration from this result because the 222.5 nm absorbance corresponds to the concentration of the unsaturated compounds such as the benzene ring in the DOM incorporated in the DS solutions. The strong correlation between the 400 nm absorbance and the DS concentration, shown in Fig. 2, suggests that this absorbance corresponds to the visible DS. Since DS concentration corresponds well to DOM concentration, as indicated above, the absorbance at 400 nm also corresponds to the DOM concentration. This shows that we succeeded in eliminating the influence of DOM when measuring the DBS concentration using the proposed method.

324 The slope of the linear relationship between the DS concentration and the 222.5 nm absorbance of the DBS-DOM complex solution with the same DBS and NaCl 325 326 concentrations was the same among the solutions with different DBS concentrations (Fig. 1; Table 1). The same slope confirms that the absorbance increases in proportion 327 to the increase in DBS concentration, even with the presence of DOM in the solution; 328 that is, the increases in absorbance at 222.5 nm as the DBS concentration increased, 329 were same among the solutions. This also indicates that the NaCl concentration did not 330 331 affect the increase in absorbance as the DBS concentration increased.

The experimental result provides an insight into the relationship between higher and lower concentrations of electrolyte solutions as the extractant of DOM from soil. A reduction in DS concentration was observed when using the 100 mmol NaCl/L solution as an extractant (Figs. 1 and 2). This was caused by the shielding effect exerted by the higher electrolyte concentration, which weakened the repulsive electrostatic forces among the negatively charged aggregated organic matters in the soil, making it difficult for the DS to dissolve into the solution (Ahmed et al., 2012).

339 Stronger positive correlations between the DS concentration and the absorbances at 340 222.5 nm and 400 nm were observed in the present study under lower concentrations 341 of the electrolyte solution (Fig. 1; Table 1). It was assumed that the lower DS 342 concentrations at higher NaCl concentrations resulted in a weaker correlation (Table 1) due to the decreased accuracy of measurement of smaller DS weights in the case of
the higher NaCl concentration. In addition, the higher correlation between the
absorbances of two spectra indicates that both absorbances are mainly correlated to
DOM concentration, which is supposed to be more accurate than DS concentration
(Table 1).

348 The proportion of the DOM in DS is supposed to differ between the different NaCl 349 concentration values. This might be caused by the difference in the slope (Table 1). As mentioned earlier, due to the shielding effect, DS and DOM dissolution from the soil 350 decreases with an increase in electrolyte concentration. The decrease in DOM is 351 supposed to be larger than DS because the structure of DOM is more flexible, and 352 353 hydrophobic attraction among humic substances, including DOM, increases with an increase in electrolyte concentration. Therefore, the proportion of DOM in the DS in 354 355 the DOM solution decreases. The reason for these findings may be the difference in the 356 conformation of the DOM. The structure of DOM shrinks when the electrolyte concentration is larger due to the shielding effect, because the expanding electrostatic 357 force among the charged sites in the DOM molecule is smaller; consequently, this 358 change in conformation might affect the absorbance values. Moreover, the solution pH 359 might affect the DOM conformation, as the electric charge of DOM is pH-dependent 360 (Ghosh and Schnitzer, 1980). Therefore, the DOM standard curve must be prepared 361 under the same solution condition for this measurement. The difference of the slope for 362 the 222.5 nm absorbance vs. 400 nm absorbance was smaller (Table 1). The closer 363 364 values also indicate that both absorbance values were strongly correlated to the DOM 365 concentration.

As shown in Fig. 5 (b), for the 10 mmol NaCl/L solution, the deviation of the measured 222.5 nm absorption from the standard DBS line, caused by the influence of

368	DOM, was very small due to the lower DS concentration. However, the calculated DBS
369	values for the DBS-DOM complex solution were well adjusted with the proposed
370	method, as shown in Fig. 6 (b). Thus, it can be concluded that the developed method
371	was successfully applied.
372	

5. Conclusions

In the study, we propose a method for the measurement of the DBS concentration of a solution containing DOM by measuring the absorbances at 222.5 nm and 400 nm, without any reagents. The absorbance values at 222.5 nm have been extensively used for DBS measurement because the approach is rather straightforward.

380 The proposed measurement method is very simple because it involves 381 measurement of absorbance at only two different wavelengths, without the use of any reagents. The DOM is commonly observed in natural waters and soil waters. The DBS 382 383 concentration of such waters could be easily measured using the proposed method even when the solution includes a non-negligible amount of DOM. Significantly, the method 384 is very effective for the batch DBS adsorption experiment of humic soils because the 385 DOM is dissolved considerably when mixing soil and water. This proposed method 386 could also provide insights into the spectrometric measurement of other organic 387 388 pollutants, more precisely, in solutions which contain a considerable quantity of DOM. We also consider that our simple, rapid, and reagent-free method characterises a way 389 forward in soil and water pollution chemistry because of the possibility to integrate 390 these algorithms with PC-controlled or stand-alone UV spectrophotometry. This will 391 allow the direct, instant, and precise measurement of DBS from practical environmental 392 samples of natural waters and industrial effluents. However, there is scope for further 393 improvement of the method through investigations with various DOM concentrations 394 from other sources and under different pH conditions. 395

396

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Table 1: The coefficient of determination (R²) and slope range from the regression
analyses between dissolved solid (DS) concentration and absorbances (Abs.) at 222.5
nm and 400 nm spectra for 0.1 mmol NaCl/L and 10 mmol NaCl/L conditions
(summarized from Figure 1, 2, and 3).

Regression between	R ² range (Min.–Max.)		Slope range (Min.–Max.)	
	0.1 mmol NaCl/L	10 mmol NaCl/L	0.1 mmol NaCl/L	10 mmol NaCl/L
DS conc. vs. Abs. at 222.5 nm	0.992-0.995	0.398-0.917	0.021–0.022	0.0029–0.0033
DS conc. vs. Abs. at 400 nm	0.986-0.989	0.807–0.896	0.0036–0.0037	0.00036-0.00037
Abs. at 222.5 nm vs. Abs. at 400 nm	0.989–0.997	0.661–0.949	5.9	7.8–9.8

566	FIGURE CAPTIONS
567	
568	Figure 1: Effects of dissolved solids (DS) and dodecylbenzenesulfonate (DBS)
569	concentrations on the 222.5 nm spectrum for the 0.1 mmol NaCl/L and 10 mmol NaCl/L
570	conditions.
571	Figure 2: Effects of dissolved solids (DS) and dodecylbenzenesulfonate (DBS)
572	concentrations on the 400 nm spectrum for the 0.1 mmol NaCl/L and 10 mmol NaCl/L
573	conditions.
574	Figure 3: Relationships between the absorbance at 222.5 nm and 400 nm UV-vis
575	spectra measured with respect to the dodecylbenzenesulfonate (DBS) concentration in
576	the 0.1 mmol NaCl/L and 10 mmol NaCl/L solutions.
577	Figure 4: Linear regression relationships established from the absorbance values at
578	222.5 nm and 400 nm to eliminate the influence of dissolved solids (DS) in the
579	dodecylbenzenesulfonate (DBS)-DOM complex solutions.
580	Figure 5: Relationship between the actual and measured dodecylbenzenesulfonate
581	(DBS) concentrations for DBS–DOM complex solutions with (a) 0.1 mmol NaCl/L and
582	(b) 10 mmol NaCl/L before the elimination of the influence of dissolved solids (DS).
583	The dotted line is the standard DBS curve.
584	Figure 6: The calculated dodecylbenzenesulfonate (DBS) concentration compared to
585	the respective actual values for the DBS-DOM complex solutions with (a) 0.1 mmol
586	NaCl/L and (b) 10 mmol NaCl/L after the elimination of the influence of dissolved
587	solids (DS). The dotted line is the standard DBS curve.
588	



Figure 1: Effects of dissolved solids (DS) and dodecylbenzenesulfonate (DBS)
concentrations on the 222.5 nm spectrum for the 0.1 mmol NaCl/L and 10 mmol NaCl/L
conditions.



concentrations on the 400 nm spectrum for the 0.1 mmol NaCl/L and 10 mmol NaCl/Lconditions.



Figure 3: Relationships between the absorbance at 222.5 nm and 400 nm UV-vis
spectra measured with respect to the dodecylbenzenesulfonate (DBS) concentration in
the 0.1 mmol NaCl/L and 10 mmol NaCl/L solutions.



Figure 4: Linear regression relationships established from the absorbance values at
222.5 nm and 400 nm to eliminate the influence of dissolved solids (DS) in the
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