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Factor analysis of linear alkylbenzene sulphonate (LAS) vertical distribution in coastal sediments of Cadiz Bay (southwest Spain)

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ABSTRACT

Very little is known concerning the behaviour of linear alkylbenzene sulphonate (LAS) in coastal systems, and even less when we consider the sedimentary field only. In the present study, a factor analysis is applied to the results obtained for different variables at three stations, both in the sediment and in interstitial water, with the aim of evaluating their relationship with LAS. The variables analysed have two main types of distribution in the sedimentary area in relation to depth: linear and/or exponential. LAS is, in most cases, associated with both types of distribution, indicating that its concentration decreases with depth, especially in the surface layer.

Key words: LAS, coastal sediments, factor analysis, vertical profile.

RESUMEN

Análisis factorial de la distribución vertical del alquilbenceno lineal sulfonato (LAS) en sedimentos costeros de la bahía de Cádiz

El comportamiento del alquilbenceno lineal sulfonato (LAS) en los sistemas costeros no se conoce con precisión, y este conocimiento es aun menor si nos restringimos al compartimento sedimentario. En este trabajo se aplica un análisis factorial a los resultados obtenidos para distintas variables determinadas en tres estaciones, tanto en sedimento como en agua intersticial, con el objetivo de evaluar sus interrelaciones con el LAS. Las variables analizadas presentan dos modos principales de distribución con la profundidad en el compartimento sedimentario: lineal y/o exponencial. En casi todos los casos, el LAS se asocia a ambos modos de distribución, lo que indica que su concentración sufre una disminución con la profundidad, pero se produce de forma especialmente acusada en la capa superficial.

Palabras clave: *LAS, sedimentos costeros, análisis factorial, perfiles verticales.*

INTRODUCTION

Linear alkylbenzene sulphonate (LAS) is one of the major anionic surfactants used in domestic detergent formulations. In 1994 its production in Western Europe reached 450 000 t (Schulze, 1996), and its average consumption in Spain is 5.6 g inh^{-1} day^{-1}. Urban wastewater, especially untreated waste, is the most important medium for this compound to access aquatic environments.

The main mechanisms through which this surfactant is removed from the environment are biodegradation and sorption to sediments or suspended material. LAS undergoes complete mineralisation under certain conditions (Painter, 1992; Swisher, 1987). High percentages of biodegradation (95-99 %) have been reached in aerobic wastewater treatment plants (Di Corcia, Samperi and Marcomini, 1994; Feitjel *et al.*, 1996). However, there is some disagreement regarding the speed and extent of the degradation process when environmental conditions vary. Thus, Kolbener *et al.* (1995a,b) detected, at the end of the degradation process, the presence of 3.2 % of the initial organic carbon, which confirms the results previously obtained by Schöberl (1993). In marine settings LAS degradation is slower than in fresh water (Vives-Rego *et al.,* 1987), and some authors have reported that under anoxic conditions, biodegradation speed is even lower (Bruce, Swanwick and Ownsworth, 1966; Larson *et al.*, 1993).

The adsorption process of this surfactant to the sediment is influenced by the physico-chemical properties of the sediment, by those of the surfactant itself, and by those of the solution with which it is in contact. Due to the clayey and anoxic nature of the sediments of Cadiz Bay, which have been found to experience intense and irreversible LAS adsorption (Rubio, González-Mazo and Gómez-Parra, 1996), they are especially interesting in terms of surfactant accumulation.

Our research was aimed at studying the influence of certain environmental variables on LAS vertical distribution in sediments. To this end, a factorial analysis was used to evaluate and interpret data variability. Factorial analysis is one of the major statistical techniques used in environmental studies, making it possible to explain simply the relationships among a number of variables.

MATERIALS AND METHODS

Study area

The present study was conducted in took place in Cadiz Bay (Spain), at three stations located in Sancti Petri sound (figure 1), into which the wastewater effluents of the city of San Fernando (100 000 inhabitants) are discharged directly. Station A, located south of Sancti Petri sound, has the lowest pollution rate. Station B, located in the centre, is close to the effluent outfall. Finally, station C is located north of the sound, near the inner cove of Cadiz Bay.

At each station, 10 sediment cores were collected using a gravity corer. Each core was cut into portions 1 cm thick, 10 of which were selected, ranging from surface level to a depth of approximately 21 cm. Interstitial water was extracted using a centrifuge to separate the liquid phase, called interstitial water, from the solid phase, sediment. Then all sediment and interstitial water cores from the same

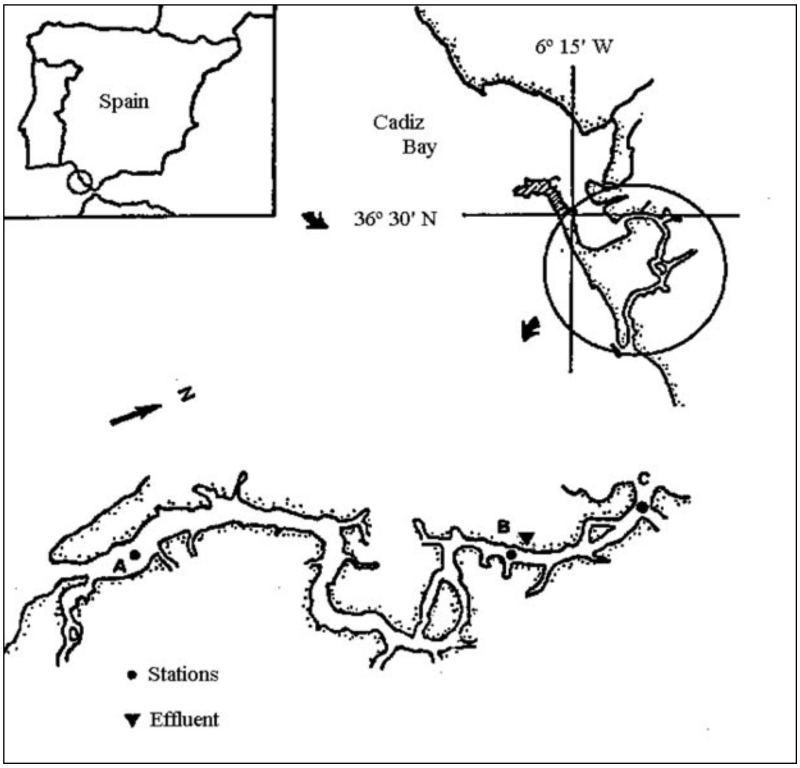

Figure 1. Map of Cadiz Bay, showing the sampler points along of the Sancti Petri Sound

station and depth were put together in order to have a more representative sample.

Besides depth (DEP) and porosity (POR), the variables measured were:

- in sediment: total carbon (TC), total hydrogen (H), total nitrogen (N), organic carbon (OC) and LAS (LASsed)
- in interstitial water: inorganic carbon (IC), carbon dioxide partial pressure (CO_2), bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), phosphate (HPO_4^{2-}), alkalinity (ALK), ammonium (NH_4^+), sulphate (SO_4^{2-}), pH (pH), silicate (SiO^2), nitrate (NO_3^-) and LAS (LASint)

Analytical methods

For LAS analysis, 6-g sediment cores underwent Soxhlet extraction with 60 ml of MeOH for 11 hours. The methanolic extract was dried using a rotary shaker, and the residuum was dissolved again in 250 ml of Milli-Q water. Both sediment and interstitial water (25 ml) solutions were acidified to pH 3, then purified and concentrated by solid-phase extraction, following González-Mazo *et al.* (1997).

LAS was measured by reverse-phase liquid chromatography, with an HP1046A fluorescence detector ($\lambda_{excitation}$ = 225 nm, $\lambda_{emission}$ = 295 nm), and a 100EC RP8 10 m-sized-particle Lichrospher column as stationary phase. The mobile phase was a solution of MeOH/H_2O to which 10 g l^{-1} of $NaClO_4$ were added, with a flux of 1.0 ml min^{-1}.

After pulverisation of the sediment, organic carbon was determined using the method of Gaudette *et al.* (1974), later modified by El Rayis (1985). Carbon, N and H contents in the sediment were measured with a Carbo Erba element analyser, Mod. 1106. Interstitial water nutrient analysis (NH_4^+, HPO_4^+, NO_3^- and SiO_2) was carried out using a Technicon Traacs 800 continuous-segmented flux autoanalyser, after adapting the methods described by Grasshoff, Ehrhardt and Kremling (1983). Interstitial water sulphate concentration was measured using the typical gravimetric method after modification. Total alkalinity and inorganic carbon in interstitial water were measured with an automatic titrator (Metrohm, 670 Tiroprocesador) of potenciometric titration curves, with HCl 0.1M.

All variables measured at each station, including those from sediments and interstitial water, underwent a multivariant statistical analysis, consisting of a factorial analysis made at the University of Cadiz Computer Centre with the BMDP statistical software package installed in the VAX system. This analysis was applied to every station, using a matrix of all studied variables.

RESULTS

Tables I, II and III show the results obtained using the variables from the sediments analysed at stations A, B and C, respectively. These data were used in the statistical analysis.

Figure 2 shows the profiles of some of the variables measured. There are two clear variation trends in relation to depth: linear (A) and exponential (B).

The factorial analysis applied to the 19 variables measured at station C provides us with two factors corresponding to 87 % of the variance (table VI). Factor 1 corresponds to 74.6 % of the variance. The variables related to this factor are, in order of importance: inorganic carbon, carbonates, alkalinity, bicarbonates, ammonium, depth, porosity, organic carbon, pH, sulphates, silicates and nitrates. All of them are directly correlated, except porosity, organic carbon, sulphates and nitrates, which have negative correlations.

Factor 1 brings together all variables with linear variation in relation to depth, as shown in figure 2A. This linear evolution derives from the initial diagenetic processes that affect the organic matter throughout the sedimentary column. Thus, aerobic oxidation, nitrate-reduction, sulphate-reduction and methane-genesis are represented. Aerobic oxidation process is included in this factor when it is not significant enough to alter variable linearity with depth; otherwise, it is not included. Nitrate is used in nitrate-reduction as an organic matter oxidant agent, which has several consequences: nitrate concentration decreases, nitrogen disappears from the system as molecular nitrogen, and ammonium presence increases. Sulphate-reduction takes place to a lower depth, and uses sulphate as the oxidant agent, which later becomes sulphydric acid, resulting in a decrease in the sediment sulphate concentration. In general, it can be said that this factor characterises the sediment diagenetic process.

Factor 2 is associated with total nitrogen, carbon dioxide partial pressure, total carbon, hydrogen

Table I. Matrix with the average values of the sediment variables, used for the statistical analysis at station A

Depth (cm)	0.5	1.5	2.5	3.5	5.5	7.5	10.5	13.5	17.5	21.5
Por.	0.673	0.623	0.591	0.587	0.580	0.562	0.535	0.523	0.500	0.487
OC (%)	1.40	1.47	1.57	1.48	1.42	1.46	1.37	1.68	1.61	1.34
C (%)	3.432	3.447	3.439	3.426	3.598	3.626	3.456	3.475	3.455	3.399
N (%)	0.024	0.023	0.009	0.009	0.009	0.014	0.001	0.004	0.000	0.000
H (%)	0.756	0.761	0.756	0.785	0.769	0.772	0.672	0.710	0.719	0.693
PO_4^- (µM)	6.810	5.548	7.497	6.091	7.576	9.502	11.157	11.522	16.962	18.767
SiO_2 (µM)	31.94	46.89	48.09	49.14	55.86	58.47	62.71	65.87	76.43	78.16
NO_3^- (µM)	4.057	8.089	6.576	4.246	7.580	10.780	3.524	2.552	5.540	1.984
SO_4^{2-} (mM)	30.896	29.581	28.326	28.004	27.000	24.236	21.357	19.562	16.542	–
NH_4^+ (mM)	0.342	0.276	0.248	0.242	0.185	0.287	0.393	0.493	0.745	0.959
Alk. (mM)	2.835	2.946	2.988	3.100	3.294	3.524	3.817	4.083	5.190	5.854
IC (mM)	2.235	2.298	2.287	2.368	2.450	2.561	2.638	2.694	3.510	3.926
pH	8.298	8.317	8.365	8.369	8.379	8.416	8.412	8.498	8.546	8.550
CO_3^{2-} (mM)	0.426	0.453	0.493	0.514	0.541	0.604	0.618	0.732	1.033	1.163
HCO_3^- (mM)	1.803	1.838	1.789	1.848	1.902	1.951	2.014	1.957	2.472	2.757
CO_2 (mM)	6.522	6.365	5.545	5.677	5.711	5.378	5.603	4.466	5.051	5.583
LAS_{sed} (ppm)	0.875	0.754	0.911	0.470	0.508	0.678	0.662	1.069	0.936	0.950
LAS_{int} (ppb)	35.5	29.5	25.6	13.8	13.1	19.4	23.7	23.3	18.1	20.5

Table II. Matrix with the average values of the sediment variables, used for the statistical analysis at station B

Depth (cm)	0.5	1.5	2.5	3.5	5.5	7.5	10.5	13.5	17.5	21.5
Por.	0.743	0.727	0.698	0.694	0.667	0.636	0.602	0.576	0.550	0.552
OC (%)	2.81	2.61	2.90	2.90	2.72	2.74	2.71	2.53	2.36	2.38
C (%)	3.94	4.09	3.86	4.16	4.32	4.31	4.47	4.31	4.51	4.09
N (%)	0.12	0.07	0.06	0.06	0.03	0.02	0.01	0.00	0.00	0.06
H (%)	1.05	1.01	0.97	1.04	0.96	0.95	0.97	0.93	0.91	0.96
PO_4^- (µM)	13.8	11.7	19.0	28.0	37.4	43.9	52.4	54.3	46.2	51.4
SiO_2 (µM)	17.4	22.8	36.1	45.4	70.8	83.9	97.3	117.4	111.3	117.8
NO_3^- (µM)	7.0	7.1	4.0	18.2	4.8	2.7	4.2	4.7	3.7	2.5
SO_4^{2-} (mM)	31.835	28.457	27.457	22.757	16.523	11.231	7.452	6.322	4.526	2.214
NH_4^+ (mM)	0.576	0.634	0.712	1.072	0.995	1.393	2.009	2.450	2.401	2.661
Alk. (mM)	2.570	2.959	2.621	2.907	3.881	4.739	8.150	9.803	11.688	12.657
IC (mM)	1.383	1.671	1.517	1.661	2.106	2.596	4.250	5.098	6.275	6.517
pH	8.697	8.691	8.718	8.817	8.823	8.824	9.020	9.052	9.038	9.135
CO_3^{2-} (mM)	0.549	0.751	0.603	0.689	1.004	1.234	2.484	3.053	3.783	4.213
HCO_3^- (mM)	0.833	0.918	0.913	0.971	1.101	1.360	1.765	2.044	2.491	2.300
CO_2 (mM)	1.134	0.979	1.248	1.242	1.099	1.361	1.133	1.228	1.474	1.135
LAS_{sed} (ppm)	130.753	127.816	150.694	158.917	125.233	128.223	40.733	22.059	16.709	55.310
LAS_{int} (ppb)	33.7	30.2	42.5	54.5	65.8	42.103	28.4	31.3	13.9	38.1

and sulphates (with positive correlation), and also phosphates, pH and silicates (with negative correlation). The variables associated with this factor are those with sharp gradients on their surface, which remain practically constant as depth increases, as shown in figure 2B. Factor 2 represents aerobic oxidation, which is the most effective process in organic matter oxidation among those taking place in the sedimentary column. Thus, it is associated with the final products of the process, which have their origin mainly in the outer surface layer.

The relationship between these two factors is obtained by distributing the variables in the factor area, using correlations between variable and axes as co-ordinates. As shown in figure 3, most variables are associated with both factors, with different sign for each one. This kind of distribution has been found at all three stations.

Table III. Matrix with the average values of the sediment variables, used for the statistical analysis at station C

Depth (cm)	0.5	1.5	2.5	3.5	5.5	7.5	10.5	13.5	17.5	21.5
Por.	0.729	0.729	0.726	0.718	0.713	0.687	0.664	0.643	0.623	0.611
OC (%)	2.87	2.82	2.84	2.73	2.63	2.80	2.70	2.38	2.46	2.20
C (%)	4.64	4.47	4.44	4.37	4.31	4.28	4.44	4.52	4.40	4.45
N (%)	0.13	0.12	0.11	0.10	0.07	0.08	0.07	0.08	0.06	0.09
H (%)	1.01	0.98	0.97	0.96	0.92	0.94	0.90	0.88	0.88	0.90
PO_4^- (μM)	11.7	20.2	31.0	39.6	49.5	60.1	74.1	75.1	83.1	81.2
SiO_2 (μM)	31.9	44.4	54.4	72.4	81.1	108.5	133.0	153.3	166.9	160.5
NO_3^- (μM)	5.0	5.4	6.5	13.7	5.3	4.6	7.6	3.1	4.6	2.8
SO_4^{2-} (mM)	31.229	29.865	28.841	28.456	25.103	14.807	9.562	7.621	6.920	5.751
NH_4^+ (mM)	0.558	0.559	0.581	0.652	0.747	1.073	1.466	1.953	2.470	2.543
Alk. (mM)	2.675	3.164	3.194	3.476	4.451	4.944	7.307	9.090	12.286	15.491
IC (mM)	2.040	2.357	2.379	2.442	2.792	2.948	4.206	5.216	7.220	8.721
pH	8.445	8.438	8.489	8.532	8.626	8.727	8.791	8.830	8.893	9.031
CO_3^{2-} (mM)	0.543	0.630	0.692	0.761	1.005	1.224	1.899	2.471	3.683	5.134
HCO_3^- (mM)	1.463	1.723	1.683	1.677	1.784	1.721	2.305	2.742	3.534	3.585
CO_2 (mM)	3.544	4.242	3.685	3.323	2.849	2.179	2.517	2.738	3.052	2.253
LAS_{sed} (ppm)	26.492	23.174	17.390	12.884	12.191	4.450	4.575	3.185	2.603	3.338
LAS_{int} (ppb)	57.4	29.1	27.6	32.8	34.1	34.4	28.0	19.7	20.4	21.0

Figure 4 features a graphic with the values of factors 1 and 2 in each case (variables from a specific station), grouped together according to their depth. Factor 1 increases with depth and has a slight inversion at the surface layer, where factor 2 is very important, above all in the first 3 cm. This strengthens the aforesaid explanation of the factors.

LAS from both sediment and interstitial water is associated with these two factors, which shows that its concentration decreases with depth, more notably on the surface layer. Concentration decrease in the first centimetres is more acute in sediment LAS, and therefore its correlation with factor 2 is substantially higher than with factor 1.

The fact that LAS concentration decreases with depth may be due either to degradation processes, which occur mainly in the oxic layer, or simply to an increase in LAS contribution to the sound throughout the time.

Three factors were obtained at station B, corresponding to 88.3 % of the variance (table V). As was the case at station C, factor 1 corresponds to a high percentage of the variance (72.3 %). Factors 2 and 3 are less significant, since they correspond to

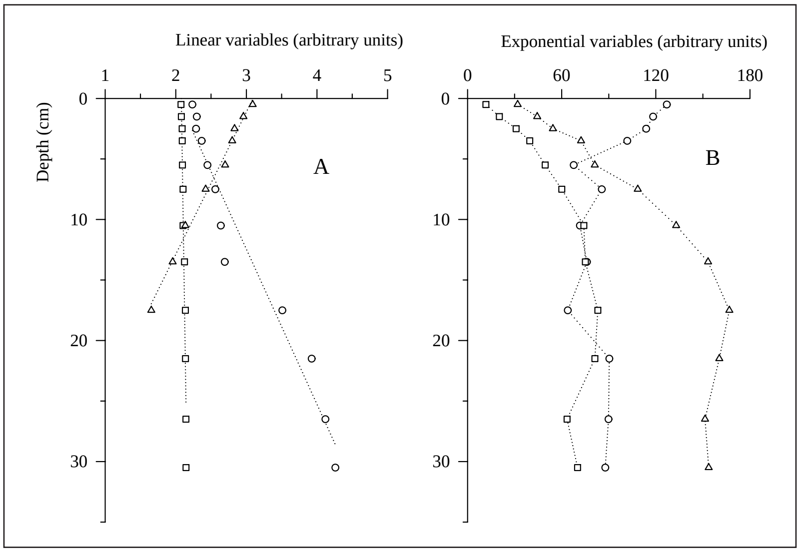

Figure 2. Different examples of depth distribution in the sedimentary compartment: linear (A) and exponential (B)

Table IV. Results of the factor analysis at station A. The values shown are the correlation coefficients of each variable in relation to the factor. Variables with an asterisk (*) correspond to interstitial water, the rest to sediment

Variable		Factor 1	Factor 2	Factor 3	Factor 4
Bicarbonates	*	0.971	0.000	0.000	0.000
Inorganic Carbon	*	0.956	0.000	0.000	0.000
Phosphate	*	0.943	0.000	0.000	0.000
Alkalinity	*	0.937	–0.262	0.000	0.000
Carbonates	*	0.917	–0.256	0.267	0.000
Ammonium	*	0.892	0.000	0.306	–0.275
Depth		0.867	–0.398	0.000	0.000
Sulphates	*	–0.855	0.407	0.000	0.000
pH	*	0.796	–0.460	0.386	0.000
Silicates	*	0.793	–0.546	0.000	0.000
Porosity		–0.710	0.642	0.000	0.000
LAS	*	0.000	0.846	0.000	–0.356
Nitrogen		–0.562	0.734	0.000	0.287
CO_2	*	–0.452	0.659	–0.575	0.000
Organic Carbon		0.264	0.000	0.912	0.000
LAS		0.329	0.378	0.781	–0.301
Nitrates	*	0.000	0.000	0.000	0.930
Hydrogen		0.000	–0.313	0.000	0.795
Total Carbon		–0.585	0.000	0.000	0.647
% Variance		65.38	14.85	7.04	6.75

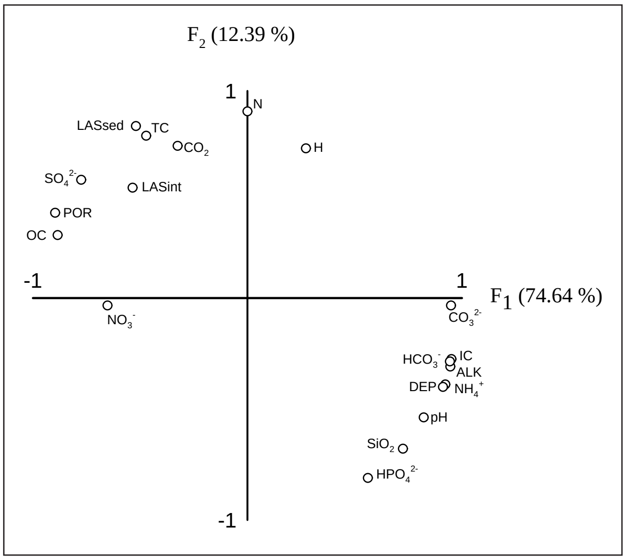

Figure 3. Variables distribution in the factors space (using variables and factor correlations as coordinates)

8.7 and 7.3 %, respectively. Factor 1 is associated with the same variables and in the same way as in the previous case. Thus, in this case too, it logically represents the diagenetic processes of the whole sedimentary column.

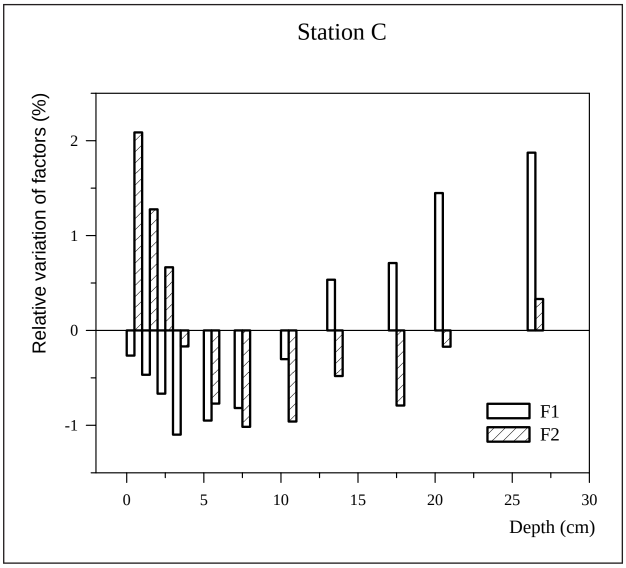

Figure 4. Factors 1 and 2 distribution versus depth for the different station C cases (pull of variables that corresponds to the same station)

At this station, factor 2 corresponds to the one at station C in terms of associated variables. The absolute values of the correlation coefficients between variable and factor are also very similar.

Factor 3 brings together those variables which evolve irregularly with depth, since they do not match any of the distributions described up to now. Its associated variable, with negative correlation, is carbon dioxide partial pressure.

Sediment LAS concentration decreases with depth, and therefore it is mainly associated with the first factor. This decrease is not as important in the first centimetres as it was at station C, perhaps due to a thinner oxic layer. Thus, this variable is not so clearly associated with factor 2 as in the previous case. On the other hand, interstitial water LAS is directly associated with factor 3. The irregular distribution at this stage is explained by the low surfactant concentrations obtained, being three magnitude orders lower than those in the sediment.

Lastly, four factors were found in the analysis applied to station A variables (table IV). The increase in the number of factors shows a more heterogeneous variable distribution than in the previous cases. Factor 1 corresponds to 65.4 % of the variance, and is as significant as in the previous cases, since the results of both variables and ways of associating coincide with those obtained at station C, with the exception of organic carbon and nitrates.

Table V. Results of the factor analysis at station B. The values shown are the correlation coefficients of each variable in relation to the factor. Variables with an asterisk (*) correspond to interstitial water, the rest to sediment

Variable		Factor 1	Factor 2	Factor 3
Carbonates	*	0.947	0.300	0.000
Alkalinity	*	0.940	0.321	0.000
Depth		0.935	0.259	0.000
Organic Carbon		–0.932	0.000	0.000
Inorganic Carbon	*	0.930	0.336	0.000
Ammonium	*	0.909	0.380	0.000
pH	*	0.883	0.425	0.000
Bicarbonates	*	0.878	0.420	0.000
Porosity		–0.847	–0.514	0.000
Sulphates	*	–0.778	–0.598	0.000
LAS		–0.759	–0.443	0.263
Silicates	*	0.749	0.634	0.000
Nitrogen		–0.287	–0.916	0.000
Phosphates	*	0.486	0.780	0.000
Hydrogen		0.456	0.728	0.000
Total Carbon		–0.634	–0.650	0.000
LAS	*	0.000	0.000	0.903
CO_2	*	0.000	0.489	–0.705
Nitrates	*	–0.337	–0.307	0.000
% Variance		72.28	8.67	7.33

Table VI. Results of the factor analysis at station C. The values shown are the correlation coefficients of each variable in relation to the factor. Variables with an asterisk (*) correspond to interstitial water, the rest to sediment

Variable		Factor 1	Factor 2
Carbonates	*	0.951	–0.250
Alkalinity	*	0.949	0.000
Depth		0.946	–0.285
Organic Carbon		0.944	–0.261
Inorganic Carbon	*	0.923	–0.368
Ammonium	*	0.912	–0.380
pH	*	–0.896	0.432
Bicarbonates	*	–0.885	0.328
Porosity		0.822	–0.522
Sulphates	*	–0.775	0.586
LAS		0.725	–0.668
Silicates	*	–0.652	0.000
Nitrogen		0.000	0.905
Phosphates	*	–0.520	0.836
Hydrogen		0.562	–0.804
Total Carbon		–0.472	0.791
LAS	*	–0.325	0.744
CO_2	*	0.273	0.732
Nitrates	*	–0.535	0.549
% Variance		74.64	12.39

Factor 2 corresponds to 14.8 % of the variance, and its associated variables are carbon dioxide partial pressure, nitrogen and porosity. The significance of this factor is not as clear as in the previous cases, although it still seems to include variables with especially sharp variations on the surface layer. The latter factor was probably not so clearly defined at this station because of the low organic matter contribution it receives, and because it has undergone an intense degradation process in the water column before reaching this point. Thus, the gradients existing at this station are not as important as in the rest, and their evolution is either linear or irregular with depth, which influences the other factors.

Factor 3 corresponds to 7 % of the variance, and brings together, just like factor 4, the variables evolving irregularly with depth, since they do not match any of the distributions described up to now. Its associated variables are organic carbon (with positive correlation) and carbon dioxide partial pressure (with less weight and negative correlation). Factor 4 corresponds to 6.7 % of the variance, and is associated with nitrates, hydrogen and total carbon (with positive correlation).

Interstitial water LAS is also included in factor 2, with a high correlation coefficient. This shows that its concentration increases with depth, for whatever reason (e.g. aerobic biodegradation or increasing contributions). On the other hand, sediment LAS and organic carbon are the most significant variables in factor 3, which corresponds to 7.0 % of the variance and represents the organic matter levels associated with the particulate phase. This station is far from the outfall, so all organic matter that reaches this point has already undergone a previous degradation process. The LAS that reaches this station is not easily degradable and therefore it does not undergo significant biodegradation in the sediment to a lower depth.

DISCUSSION

In all three applications of the statistical analysis, factor 1 (diagenetic processes) corresponds to a high variance percentage, and brings together those variables with a linear variation in relation to depth.

The remaining factors are less important, since they correspond to smaller variance percentages, and bring together those variables whose variation is not linear throughout the sedimentary layer. Factor 2 (aerobic oxidation) is, according to our results, equally significant at all three stations, and brings together exponential variations in relation to depth.

The other factors from analysis of stations A and B correspond to situations that do not match any of the distribution patterns described previously.

The results lead to two clearly different trends in relation to vertical variations: exponential and linear. Sediment LAS concentration is associated with both kinds of distribution, both at stations B and C. Therefore, it falls throughout the sedimentary column, and mainly in the outer surface layer, perhaps due to aerobic oxidation processes. This surface gradient is higher at station C, possibly because of a thicker oxic layer, as indicated by nitrate and sulphate profiles. At station A, it is associated with a third factor, which evolves irregularly with depth.

The evolution of interstitial water LAS concentration with depth is somewhat more irregular than in the sediment. It must be noted that concentrations in this phase are of the order of ppb, with a very small variation interval. At stations A and C, LAS concentration drops, above all in the surface layer. At station B, it is associated with the third factor, because it does not have a clear distribution trend.

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