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Hydrocarbon Contamination in Sediments of Nueces Bay, Texas

V. K. Sharma,[1] S. D. Hicks,[1] W. Rivera,[1] F. G. Vazquez[2]

[1] Department of Chemistry, Florida Institute of Technology, 150 West University Boulevard, Melbourne, FL 32801, USA
[2] Institute of Marine and Limnology, National University of Mexico, Universitaria, D.F., Apartado Postal 70-305, C.P. 04510, Mexico

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The study of chemical contamination in coastal sediments provides a broader comprehension of overall health of the aquatic environment (Daskalakis and O’Connor 1995; Hostettler et al. 1999) . Chemical contamination within sediments is relatively constant compared to other environmental compartments such as water and organisms (Wade and Giam 1989). Hydrocarbons are ubiquitous chemical components of estuarine sediments and may cause toxicity to the estuarine organisms (Grimalt et al. 1992; Kennicutt et al. 1994; Long et al. 1998) . The determination of hydrocarbon contamination is therefore imperative to understand their distribution and fate in the estuarine environment.

A number of national and international environmental monitoring programmes have been initiated to assess the ecological health of estuaries (Sericano et al. 1995). In addition, regional environmental assessments, such as the National Estuary Programs (NEP), have been developed to monitor spatial and temporal distribution of contaminant concentrations in coastal and estuarine regions of the United States (Hollyfield and Sharma 1995; O’Connor 1996). The Nueces Bay is part of the Corpus Christi Bay National Estuary Program (CCBNEP). This Bay is of great concern because of its high productivity and proximity to possible industrial and agricultural contaminant inputs. The work presented here encompasses a distribution study of aliphatic and polynuclear aromatic hydrocarbons in sediments of Nueces Bay, Texas.

MATERIALS AND METHODS

Nueces Bay is approximately 81 km^2 located on the Texas coast (Fig. 1). It receives 70 cm yr^{-1} of precipitation with an evaporation rate of 152 cm yr^{-1}. The salinity varies from 13.3 - 30.6 during the year and is influenced by intermediate levels of rainfall and freshwater inflow of the Nueces river (Mannino and Montagna 1996). Sediment influx is also dominated by the Nueces River and the surface sediments of the Nueces Bay are predominantly sandy (Mannino and Montagna 1996).

Correspondence to: V. K. Sharma

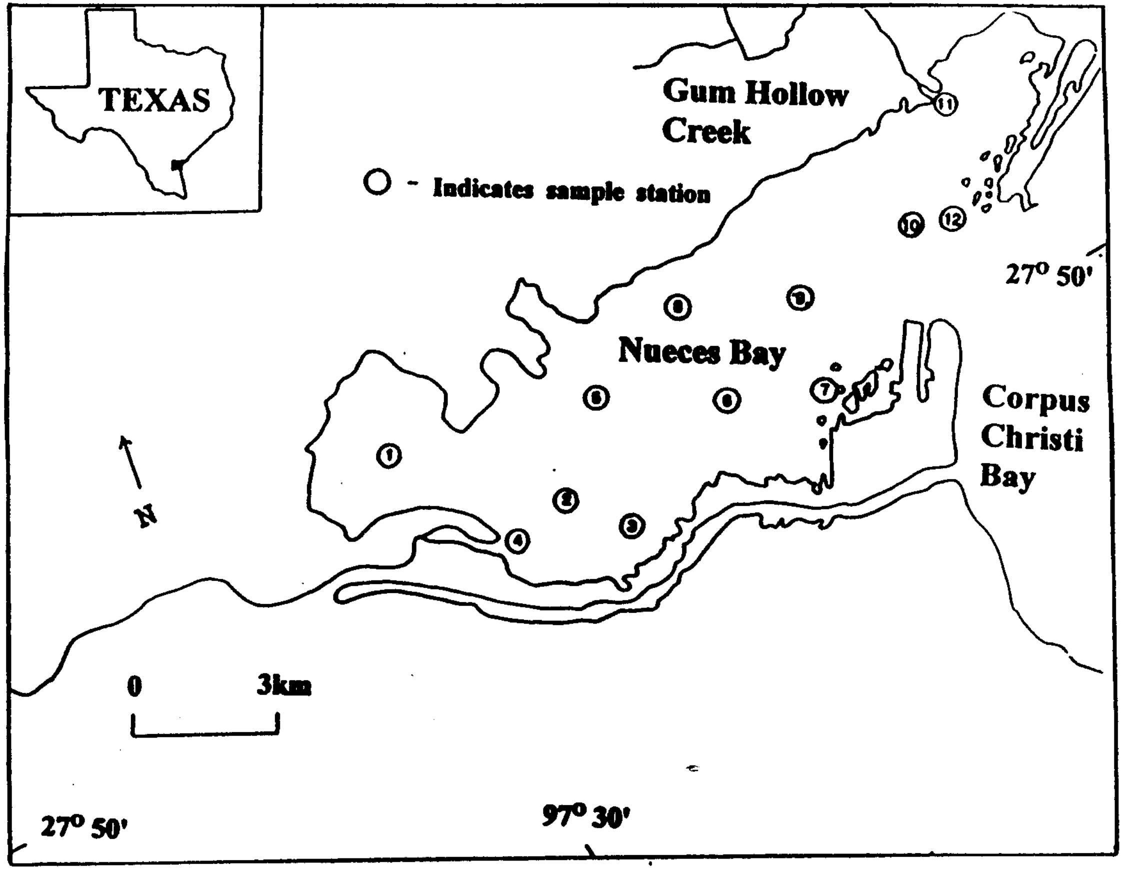

Figure 1. Map of the Nueces Bay with sampling stations

Sediment samples were collected at the 12 locations by using an Eckman Dredge (Fig. 1). A was used to collect samples. The upper 5 cm of sediment was removed and placed into a container, which had been prerinsed with methylene chloride. The container was frozen in the field and then transported to Texas A&M University at Corpus Christi for analysis.

The extraction method was similar to that used by Wade et al. (1988). A 10-g (dry weight) subsample from each sediment sample was subjected to Soxhlet extraction using methylene chloride. Each extraction was carried out for 8 h, and the sample was concentrated in hexane to 3 mL by Kuderna-Danish techniques. An alumina column clean-up procedure preceeded concentration of extract to one mL prior to analysis.

Samples were analyzed by gas chromatography (Varian 3300 GC) in the spitless mode with flame ionization detection (FID). The capillary column used was 30 m X 0.32 mm i.d. fused silica capillary column (Supelco, Inc.) Five concentrations for each analyte were used to calibrate the FID ($r \geq 0.99$). Analyte identifications were based on the retention time for each analyte. A certified sediment reference material (NIST, 1941a) was regularly submitted to the same procedure and analyzed for hydrocarbons. The variation of certified resolved hydrocarbons analysis was less than 8%.

RESULTS AND DISCUSSION

The concentrations of aliphatic hydrocarbons, n-C20-nC34 are gven in Table 1. No concentrations were detected for aliphatic hydrocarbons, n-C11 to n-C18 in any of the samples. Aliphatic hydrocarbons were found throughout the study area in which sites 1,3,5,6, and 10 had high concentrations. Nueces Bay is surrounded by oil and gas fields and these sites are closed to the produced waters discharged areas (D'Unger et al. 1996). The n-C27 and n-C29 were also the most abundant aliphatic hydrocarbons at all sites. These n-alkanes are generally produced from vascular plants and suggest terrigenous inputs (Philip 1985; Sharma et al. 1997). The source of n-C28 may be coming from the sea grass population (Quammen and Onuf 1993). However, odd and even chain hydrocarbons were equally distributed in the study area (Figure 2). This indicates that the levels of aliphatic hydrocarbons in Nueces estuary sediments are likely of both biogenic and anthropogenic sources (Clark and Blumer 1967; Philip 1985, Kennicutt et al. 1995; Sharma et al. 1997).

The concentrations of individually resolved polynuclear aromatic hydrocarbons (PAH) in sediments are given in Table 2. No concentrations were detected for any 2/3 ring polynuclear aromatic hydrocarbons. PAHs are usually into the sediments through contamination by crude oil and products of incomplete combustion products of fossil fuels (Witt 1995; Budzinski et al. 1997). Elevated concentrations of PAHs were found at site 1, 3, 5, 6, 9, and 10 (Table 1). These

Table 1. Concentrations (mg kg^{-1} dry weight) of aliphatic hydrocarbons in sediments of Nueces Bay, Texas

Site	1	2	3	4	5	6	7	8	9	10	11	12
n-C20	0.79	0.88	<0.5	0.76	0.90	<0.5	<0.5	<0.5	0.87	<0.5	0.67	<0.5
n-C21	2.96	3.84	1.22	2.87	2.92	1.16	1.94	2.12	2.98	1.25	2.59	2.03
n-C22	5.61	4.66	1.69	5.00	4.21	1.78	3.11	2.79	4.84	1.95	4.38	3.00
n-C23	8.69	6.70	2.98	7.84	5.92	3.39	4.84	3.96	7.50	3.28	6.09	4.49
n-C24	11.1	8.65	3.51	10.9	7.80	4.29	8.46	5.51	10.2	4.05	9.10	8.34
n-C25	7.62	7.32	3.41	8.97	6.31	3.97	5.23	4.32	8.80	3.44	6.01	4.73
n-C26	7.57	8.69	3.82	10.2	8.53	4.52	6.53	5.28	10.2	4.18	6.31	5.29
n-C27	10.4	13.2	5.36	16.3	12.8	7.46	10.2	7.58	16.8	6.03	10.1	7.41
n-C28	4.51	6.09	2.95	6.73	5.74	3.95	4.77	3.751	7.49	3.49	4.92	3.60
n-C29	8.07	11.3	4.27	11.7	10.7	6.15	8.74	6.34	12.5	5.10	8.02	5.36
n-C30	1.51	3.49	1.55	1.74	3.41	2.14	2.99	2.98	3.88	2.11	2.47	0.94
n-C32	1.97	3.23	1.99	2.28	3.98	2.00	2.79	1.41	2.74	<0.5	1.46	<0.5
n-C34	1.75	2.41	1.75	2.09	2.40	1.97	2.58	2.04	2.67	2.00	2.33	1.63

Table 2. Concentrations (mg kg^{-1} dry weight) of polynuclear aromatic hydrocarbons in sediments of Nueces Bay, Texas

Site	1	2	3	4	5	6	7	8	9	10	11	12
Fluoranthene	1.81	1.85	<0.5	1.75	1.62	<0.5	1.33	1.28	1.64	<0.5	1.64	1.37
Pyrene	4.06	4.50	1.53	3.97	3.49	1.13	2.29	2.20	3.09	1.55	3.16	2.17
Benzo(a) anthracene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chrysene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<
Benzo(b)fluoranthene	3.17	3.04	<0.5	3.12	2.76	<0.5	2.79	2.62	3.13	<0.5	2.58	2.68
Benzo(k)fluoranthene	1.69	1.63	<0.5	1.64	1.52	<0.5	1.51	<0.5	1.64	<0.5	1.93	<
Indeno(1,2,3-cd)pyren	<0.5	0.69	<0.5	<0.5	2.39	<0.5	0.71	0.64	<0.5	<0.5	<0.5	<
Dibenzo(a,h)anthracene	<0.5	0.36	0.73	<0.5	<0.5	0.13	1.78	2.81	<0.5	1.66	2.34	0.45
Benzo(ghi)pyrelene	0.25	0.55	0.27	0.53	0.67	0.24	0.77	0.59	0.34	0.23	0.99	0.41

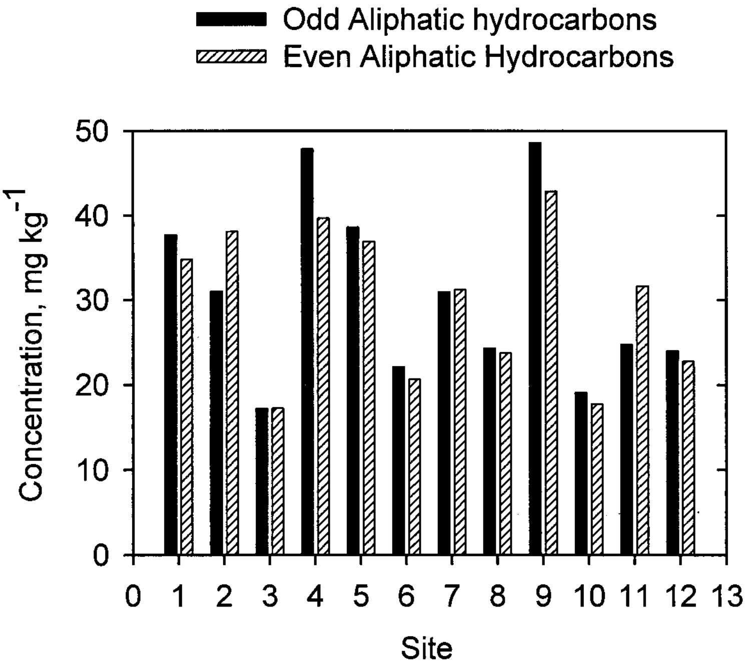

Figure 2. Aliphatic hydrocarbons in Nueces Bay, Texas.

sites are in the vicinity of drilling platforms and oil field produced water discharge wells (D'Unger et al. 1996; Chapman et al. 1991). However, dominance of pyrene over fluoranthene at all sites in the study area suggests the atmospheric input in addition to industrial discharges (Benner et al. 1989; Muel and Saguem 1985).

The total PAH concentrations varied from 1.50 - 11.2 mg kg^{-1} (Table 1). High values of PAHs were also found in Tule Lake Channel in the Corpus Christi Bay (Maruya et al. 1997). The distributions of PAHs in the south Texas estuary may be related to the commonly observed combustion or weathered petroleum sources (Blumer and Youngblood 1975). Concentrations of PAHs in our study were generally higher than values from most of the Gulf of Mexico estuaries (Sericano et al. 1995). This is consistent with contamination in estuaries from the urban area.

Concentrations of the contaminants are compared to the effects range-low (ERL) and effects range-median (ERM) concentration guidelines derived from the database of Long et al. (1995) to understand the extent of contamination (Table 3). This database contains measured concentrations and their biological effects of estuarine and marine sediments. Concentrations below the ERL value are rarely associated with biological effects. Concentrations equal to and/or above the ERL, but below the ERM, indicate a possible range in which effects would occasionally occur. The concentrations equivalent to and above ERM values indicate that the effect would occur frequently.

Table 3. Comparison of contaminants concentrations on sediments of Nueces Bay with ERL and ERM guidelines values for organic compounds (μg kg^{-1}, dry wt)

Contaminant	Minimum	Maximum	ERL	ERM
Fluoranthene	<0.5	1850	600	1500
Pyrene	1130	4500	665	2600
Benzo(a)anthracene	<0.5	<0.5	261	1600
Chrysene	<0.5	<0.5	384	2800
Dibenzo(a,h) anthracene	<0.5	2810	63.4	260
Benzo(a)pyrene	230	770	430	1600

As shown in Table 3, most of organic contaminant concentrations in the Nueces Bay were below ERM values. This suggests that the concentration ranges of most contaminants in Nueces estuary sediments would occasionally be associated with biological effects. However, concentrations of pyrene and dibenzo(a,h)anthracene were higher than ERM values. Overall, levels of pyrene and dibenzo(a,h)anthracene in the Nueces estuary sediments would likely be associated with biological effects.

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