Quantitative Data Analysis of Chemical Contamination in the Venice Lagoon: a Risk Management Perspective

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Introduction

A comprehensive risk management for the contaminants present in bottom sediments of the Venice lagoon appears to be complicated by three issues: the past, present, and future influence of human pressure; the obvious sensitivity of a wetland like the lagoon; its extension. The actual situation can be viewed as typical of stressors at regional scale.[1]

The relationships between a coastal city and its environment are one of the central question addressed in Chapter 17 of Agenda 21, adopted at the United Nations Conference on Environment and Development (UNCED).[2] In this chapter, the importance of coasts in a life-supporting system and the positive opportunity for sustainable development that coastal areas represent are stressed. However, in industrialized countries a practicable co-existence of environment and development will require mostly regulatory measures to regulate their relationships.

The Venice lagoon is one of the leading shellfish production areas in Italy, harvesting several metric tons per year of the clam *Tapes philippinarum* and the mussel *Mytilus galloprovincialis*. A number of studies in recent years have characterized the chemical contamination of matrices like biota and sediment. The chemicals analyzed belong to different families including organic contaminants (such as polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs)), chlorinated pesticides, heavy metals, organometals, etc. The primary contamination sources have been clearly identified with Porto Marghera industrial settlement and the city of Venice with its canals, motorboats, and dense anthropogenic activity. The impacts of all these activities appear to be concentrated in the central basin although the industrial area be situated at the southern boundaries of the northern basin. From the studies on sediments, the following four impact types were identified in the lagoon: industrial, urban, "not classifiable", and lagoon background.[3–7]

In this paper, the PCDD+PCDF levels found in organisms collected in the central area of the lagoon, overexposed to the primary impacts, are compared with those of specimens collected in the other two areas inside the lagoon (Figure 1). Thereby, a quantitative description of contaminant presence in the lagoon is given by an approach based on hypothesis testing.[1]

Methods

In recent years, much edible biota from the central and other lagoon areas was analyzed for its PCDD+PCDF content in research and monitoring programs: specimens included shellfish and finfish such as clams, mussels, and seabass (*Dicentrarchus labrax*). In parallel studies on lagoon sediments, site/sample classification based on exposures insisting on those areas was developed,[7] in

conformity with which the biota data dealt with in this analysis (N = 74) were grouped into (1) specimens from the central basin, under an industrial/urban impact, and (2) specimens from the northern and southern basins, under a general/aspecific impact ("not classifiable" and lagoon background). The data of interest, expressed as I-TEQs, are summarized in Table 1.

After logarithmic (*ln*) transformation, the distributions of the two data sets were subjected to descriptive statistics and normality goodness-of-fit tests (Kolmogorov-Smirnov and Shapiro-Wilks). Hypothesis testing was adopted to assess whether the data distributions were significantly different:[1] for the null (H_0) hypothesis no difference was expected to be detected between the means of the two log-transformed data sets, H_1 being the alternative one. The meaning of these two hierarchical hypotheses consisted in detecting whether a statistical difference existed between sample results grouped as described above and, if affirmative, in linking results to sampling sites to define spatial impacts. Student's *t*-test was used to evaluate whether estimates were significant.

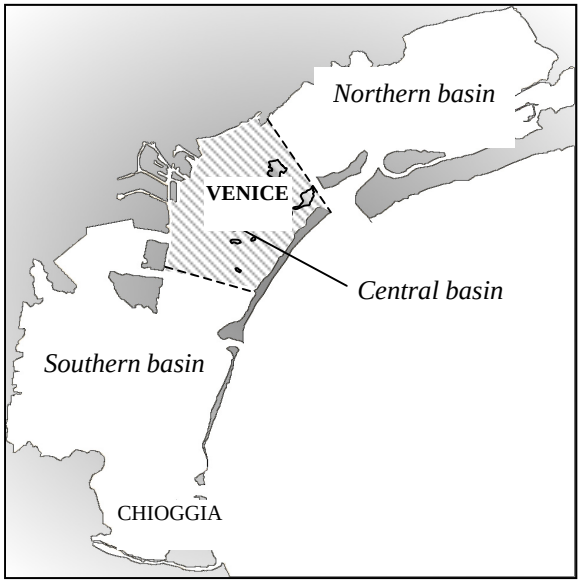

Figure 1. Layout of the Venice lagoon showing the three-basin subdivision. The central basin includes the Porto Marghera industrial settlement, the city of Venice, and a part of the Malamocco-Marghera channel.

Results and discussion

The *ln*-transformed PCDD+PCDF I-TE levels of the two data sets are plotted in Figure 2 as frequency distribution curves superimposed to histograms. In Table 2, the statistics of the distributions of interest are summarized after conversion to linear co-ordinates. The aforesaid goodness-of-fit data tests provide a significant non-evidence of non-normality for both distributions ($P > 0.05$). On the whole, while there is a considerable distribution overlapping, the average levels in central basin biota and the pertinent confidence intervals (CIs) appear to be 2–3 times higher than the corresponding descriptors of the biota from the other basins, as expected.

Table 1. PCDD+PCDF concentrations (pgI-TE/g, whole weight) in biota samples from the Venice lagoon. Specimens were obtained in different sampling campaigns between 1995 and 2002.

CENTRAL BASIN *N = 34*		**SOUTHERN BASIN** *N = 10*	**NORTHERN BASIN** *N = 30*	
0.190	0.717	0.150	0.065	0.270
0.212	0.779	0.159	0.068	0.300
0.305	0.780	0.306	0.079	0.310
0.378	0.867	0.328	0.084	0.320
0.386	0.870	0.372	0.091	0.356
0.405	0.912	0.376	0.122	0.400
0.415	0.982	0.386	0.146	0.460
0.420	1.10	0.417	0.146	0.470
0.426	1.16	0.439	0.146	0.520
0.463	1.30	1.30	0.154	0.540
0.491	1.32		0.158	0.540
0.492	1.53		0.166	0.570
0.524	1.64		0.230	0.630
0.598	1.83		0.240	0.677
0.612	1.92		0.249	1.40
0.625	2.70			
0.694	5.31			

Table 2. Statistical descriptors in linear terms of the distributions shown in Figure 2.

DESCRIPTOR	**CENTRAL** *BASIN*	**SOUTHERN AND NORTHERN BASINS**
N	34	40
X_{MEDIAN}	0.706	0.308
X_{MEAN}	0.743	0.271
Range	0.190–5.31	0.065–1.40
CI(95%)	0.577–0.957	0.213–0.345
CI(99%)	0.529–1.04	0.196–0.375
95th Percentile	3.20	1.26
99th Percentile	5.31	1.40

The statistics of the H_0/H_1 hypothesis was assessed for $P < 0.001$ and a two-sided *t*-test. The calculated *t* value of 5.927 is well above the H_0-hypothesis rejection threshold ($t^* = 3.431$), providing evidence of a statistically significant difference between the means of the two data sets. By associating I-TE results to sampling sites, the rejection of the null hypothesis also indicates the existence of a significant difference between sampling site contamination levels.

As shown, biota contamination levels seem to reflect local environmental pollutant levels, an issue also described elsewhere.[8] Therefore, the quantitative and qualitative influence of Porto Marghera and Venice on PCDD+PCDF and other chemical levels in the lagoon biota is an issue relevant to every management strategy whose target be the safe consumption of the organisms of interest and the protection of the market.

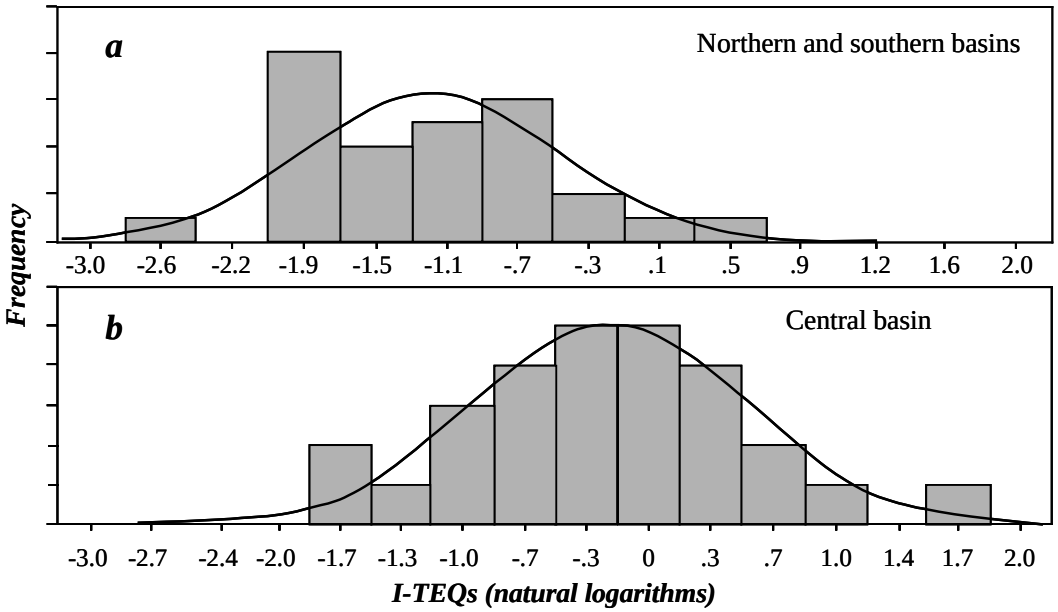

Figure 2. Log-normal distributions of PCDD+PCDF I-TE concentrations summarized in Table 1. *(a)* I-TE levels in specimens from the northern and southern basins. (*b*) I-TE levels in specimens from the central basin.

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