TRANSFER OF PCDDs AND PCDFs FROM BOTTOM SEDIMENTS TO CLAMS (*Tapes sp.*) IN THE VENICE LAGOON: A PRELIMINARY ASSESSMENT

Alessandro di Domenico and Roberto Miniero

Istituto Superiore di Sanità, 00161 Rome, Italy. E-mail: addeke@iss.it

INTRODUCTION

Since the early 1990s, our laboratory has been involved in several investigations to characterize the persistent part of Venice lagoon chemical contamination.[1,2] To this purpose, PAHs (polycyclic aromatic hydrocarbons), PCBs, PCDDs, PCDFs, some chlorinated pesticides, and several heavy metals were quantitated in a number of environmental matrices. In the framework of an ongoing research programme,[3] whose focus is on the assessment of toxicological risks the lagoon residents are exposed to, the study of the relationships between the contaminants of interest in the local biotic and abiotic components has a high priority. In this article, we have begun to analyze the aforecited relationships by comparing the PCDD and PCDF levels measured by previous investigations in congruent specimens of lagoon bottom sediments and clams.

METHODS

Analytical and TE data were taken from published works;[1,2] however, a source of a few clam results was also an inquiry of the State Attorney-General in Venice.[4] Sediment and biota specimens were collected in 1992 and 1995, in general independently from one another. Therefore, pairing of contamination values (Table 1) was carried out very carefully, by setting three priorities: *(a)* the paired sediment and biota contamination values should represent the same virtual risk area,[1,4] *(b)* they should be associated with specimens collected at relatively (!) close distance (<0.5 km) from one another, and *(c)* sampling zones should be expected to be under an even, rather constant, and well-characterized local impact. These zones are exhibited in Figure 1.

Table 1. Sediment and clam sample identification codes, and pertinent concentration levels expressed in analytical units (pg/g) and as international 2,3,7,8-T_4CDD equivalents (I-TE units).[a]

Sediment sample IDs	Clam sample IDs	Zone IDs	PCDDs+PCDFs (pg/g)[b] Sediments	Clams	PCDDs+PCDFs (pgTE/g)[b] Sediments	Clams
90	7473, 7474	1	130	3.80	1.80	0.329
10	4411	2	840	13.0	18.0	0.870
7A	7B, 7483	3	1300	19.2	24.2	1.03
40	12*, 14*	4	1400	18.0	23.0	1.09
4A, 5/1A	5/2B, 8*	5	3570	32.3	48.0	1.41
6A	7484, 9*	6	3890	24.5	56.2	1.13

(a) ID codes were reported to match original References 1, 2, and 4. *(b)* When more than one value were available in the orginal references, values were averaged. Rounding-off to three figures.

MATHEMATICAL MODELS

Linear regression analyses were carried out on the set of six X-Y pairs of (potentially correlated) analytical and TE findings, concerning bottom sediments and clams, by utilizing the canonical equation

$$y = wx + q \quad (1)$$

in a log-log field. In a linear field, Eq. (1) reverts to:

$$Y = m X^{w} \quad (2)$$

which, for $w = 1$, is the equation of a straight line through the origin. In Eqs. (1) and (2) we have: $y = \ln(Y)$, where Y = [PCDDs+PCDFs in clams, pg/g or pgTE/g, whole weight]; $x = \ln(X)$, where X = [PCDDs+PCDFs in sediments, pg/g or pgTE/g, dry weight]; $q = \ln(m)$. For $w = 1$, and replacing Y and X respectively with C_{tss} *(tissue concentration at steady state)* and C_s *(sediment concentration), the expression of the simplest bioaccumulation model is obtained:*[5]

$$C_{tss} = \text{BAF}\, C_s \quad (3)$$

Therefore, by comparing Eqs. (2) and (3) we have: $C_{tss} \equiv Y$; $C_s \equiv X$; BAF $\equiv m$. However, Eq. (3) may be corrected by introducing the two following factors: f_{lip} lipid concentration in the organism (g/g); f_{oc}, total organic carbon in sediments (g/g). Therefrom, the more sophisticated equilibrium partitioning bioaccumulation model is obtained:[5,6]

$$C_{tss} = (\text{BSAF}\, f_{lip}/f_{oc})\, C_s \quad (4)$$

RESULTS AND DISCUSSION

Figure 2 shows analytical and TE data scattergraphs, best fit lines from fitting Eq. (1), and related regression equations. According to the mean estimates of regression coefficients, Eq. (2) may be written as $Y = 0.228\, X^{0.596}$ or $Y = 0.273\, X^{0.404}$ for analytical and TE data, respectively: these are clearly non-linear relationships ($w < 1$), entailing that the rate of Y increase decreases with increasing X. In other words, in agreement with observed trends in the environment,[5] the rate of the bioaccumulation process described by Eq. (3) turns out to be greater at lower environmental concentrations than it is at the higher ones. The mean bioaccumulation factor estimates are: $BAF_{AN} = 0.23$; $BAF_{TE} = 0.27$.

By assuming the mean f_{lip} and f_{oc} values (%) to be 1.0 (f_{lip} range, 0.90–1.1 %) and 0.31 (f_{oc} range, 0.25–0.35 %),[7,8] parallel mean values of the biota-to-sediment accumulation factors may be derived from Eq. (4) as follows: $BSAF_{AN} = 0.071$; $BSAF_{TE} = 0.086$. Although at the lower end of the array of reported data, these figures appear to be in good agreement with those available for other species.[6] In fact, clams, as other filter-feeding organisms, normally exhibit a lower bioaccumulation potential. In particular, it is known that steric hindrance to large molecules, such as PCDDs and PCDFs, is a bioaccumulation limiting factor. This may be specifically applied to Venice lagoon sediments, where the PCDD and PCDF congeners with a high degree of chlorosubstitution are largely predominant.[1,2,4]

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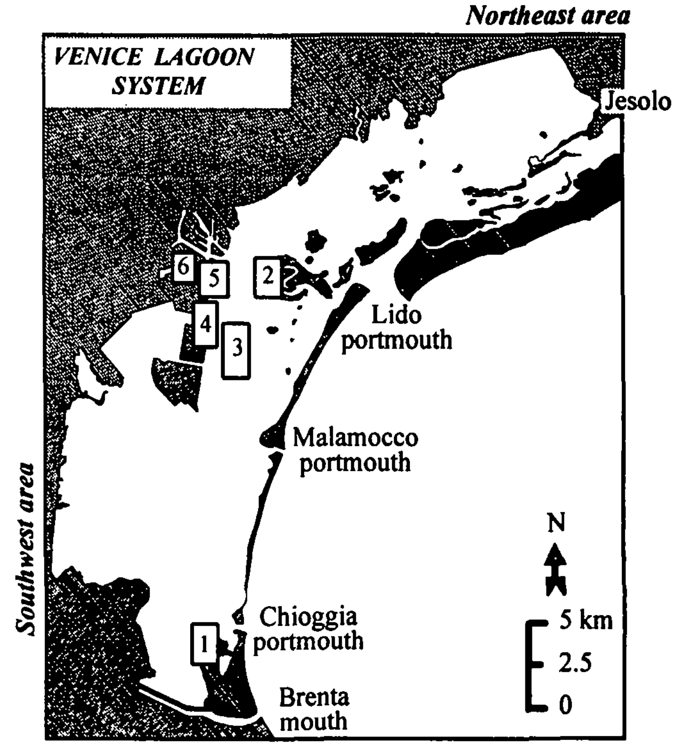

Figure 1. *Venice lagoon layout.* Following a rigorous evaluation, sampling Zones 1–6 (see Table 1) were identified and associated with the paired sediment and clam specimens at the origin of PCDD and PCDF data utilized for this study.

REFERENCES

1. di Domenico A., Turrio Baldassarri L., Ziemacki G., De Felip E., La Rocca C., Ferrari G., Cardelli M., Volpi F., Ferri F., Iacovella N., Lupi C., Rodriguez F., D'Agostino O., Sansoni R., Settimo G. *Organohalogen Compounds*, **1998**, 39, 205–210.

2. di Domenico A., Turrio Baldassarri L., Ziemacki G., De Felip E., Ferrari G., La Rocca C., Cardelli M., Cedolini G., Dalla Palma M., Grassi M., Roccabella V., Volpi F., Ferri F., Iacovella N., Rodriguez F., D'Agostino O., Sansoni R., Settimo G. *Organohalogen Compounds*, **1998**, 39, 199–204.

3. Ballard T., Cardelli M., di Domenico A., De Felip E., Ferri F., Fulgenzi A.R., Iacovella N., Miniero R., Turrio Baldassarri L., Zapponi G., Ziemacki G. *Organohalogen Compounds*, **1999**, 44, 447–452.

4. Bonamin V., di Domenico A., Fanelli R., Turrio Baldassarri L.: *Relazione di Perizia Tecnica — Microinquinanti Tossici nella Laguna di Venezia — Livelli di Contaminazione e Impatto Ambientale*, Vol. 1, **1997**. Case No. 12279/95/N RGNR, Procura della Repubblica, c/o Pretura Circondariale (Venice, Italy).

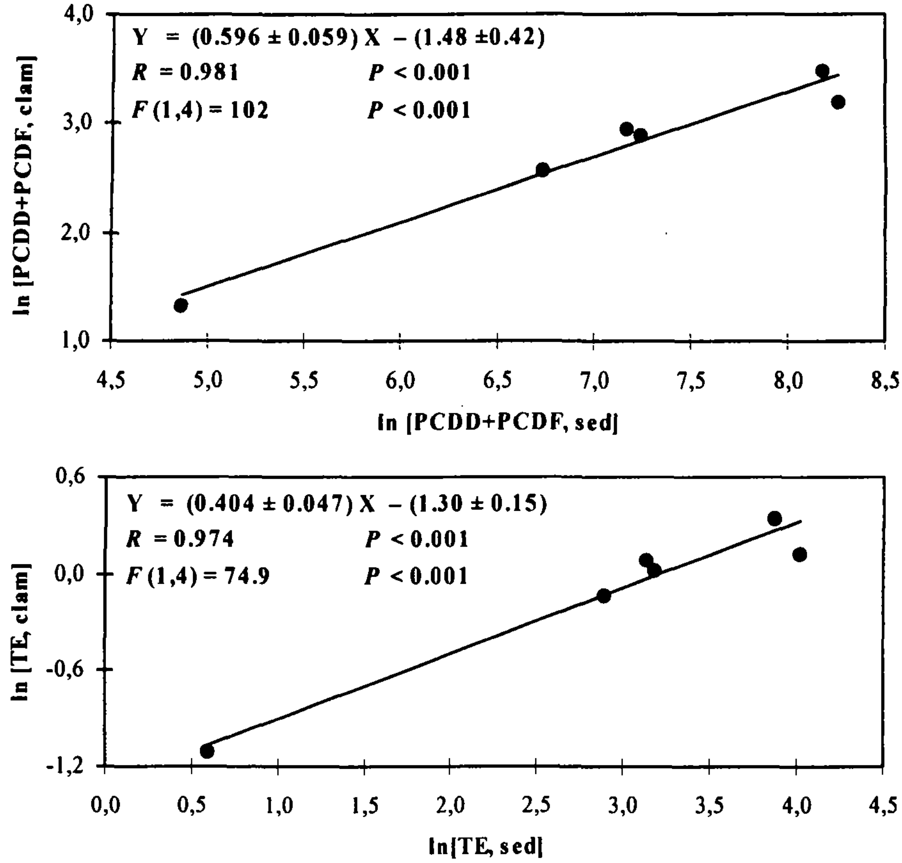

Figure 2. Correlations between PCDD and PCDF concentration values in clams and bottom sediments from the Venice lagoon. Performed in the logarithmic field on analytical (pg/g) and corresponding I-TE data sets, the linear regressions are highly significant as proven by the values of *P* for both *R* and *F*. Reverting to the linear field does not yield a straight line.

5. Lee II H.: Models, muddles, and mud: Predicting bioaccumulation of sediments-associated pollutants. In: *Sediment Toxicity Assessment*, pp. 267–293, **1992**. Barton J.A., Ed., Lewis Publishers (Chelsea, MI, USA).

6. Parkerton T.F., Connolly J.P., Thomann R.W., Uchrin C.G. *Environmental Toxicology and Chemistry*, **1993**, 12, 507–523.

7. di Domenico A., Turrio Baldassarri L., Ziemacki G.: *Relazione di Perizia Tecnica sulla Qualità e la Quantità dell'Impatto Antropico nella Laguna di Venezia*, Vol. 1, **1996**. Case No. 7105/95/N RGNR, Procura della Repubblica, c/o Pretura Circondariale (Venice, Italy).

8. Bayarri S., Turrio Baldassarri L., Iacovella N., Ferrara F., di Domenico A.: PCDDs, PCDFs, PCBs, and DDE in edible marine species from the Adriatic sea. *Chemosphere*, in press.