IS THE LAGOON OF VENICE HEALTHY? A LOOK AT BUDGETS AND PATHWAYS OF POP'S IN VENICE

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Introduction

The rapid deterioration of the world's major ecosystems has intensified the need for effective monitoring and development of operational indicators of ecosystem health[1], and the extension of health to describe regional ecosystems is a response to accumulating evidence that human-dominated ecosystems have become highly dysfunctional. The Lagoon of Venice is probably one of the world's best-known examples of an ecosystem that has been historically influenced by human intervention since the XVth century. The area has a long history of industrial activity (even recent, mainly after World War II), with oil refining and several chemical production plants around the Lagoon. Only recently has Venice also been recognised because of its environmental problems, mainly due to POPs accumulating in sediments and seafood[2,3,4,5,6], which has aroused local concern. It is well-known that one important effect of ecosystem degradation is an increased risk to the health of human populations. In the case of POPs, the simplest way for humans to be exposed is through the consumption of food contaminated by dioxins and PCBs. Due to bio-accumulation and long-term exposure (additives) to these pollutants, even minimal doses of dioxins and PCBs can result in negative effects on health.

Human health should thus be understood within an ecological framework as an expression of the life-supporting capacity of the environment. Consequently, human health becomes an important criterion of sustainability – one which, over time, signals whether we are satisfactorily sustaining the social and ecological realms[7].

This paper gathers together recent data on dioxins and PCBs, related both to the environment and to human health, in order to emphasize the need for intervention.

Results and Discussion

Several recent reviews have highlighted increasing knowledge of the fact that the Lagoon of Venice underwent high levels of dioxin and PCB pollution after World War II. In particular, in the last 10 years, after claim of sediment pollution[8], new studies of both environmental and human risks have been published. As regards sediment concentrations and atmospheric deposition fluxes, several works[9,10,11,12,13,14] have given a general picture of average data in various subzones (see Fig. 1 and Table 1).
A recently published volume[15], containing contributions from several scientists working for public monitoring and research institutes, summarised available data on industrial wastes, foodstuff contents, and possible biological disrupting effects of POPs in the Lagoon of Venice.
Most of the recent data indicate that, during the period 1950-2000, some 6 kg of I-TE have been emitted, mainly as a by-product of VCM production. Budget estimates have found most of it (~4kg) stored inside industrial channels, and more than 1 kg in lagoon sediments[9]. Thus, the average figures of the three subzones are as listed in Tab.1. The same table lists the values of sediments collected in the city canals, together with natural (background) values calculated from dated cores collected inside the Lagoon[2,12,16,17].

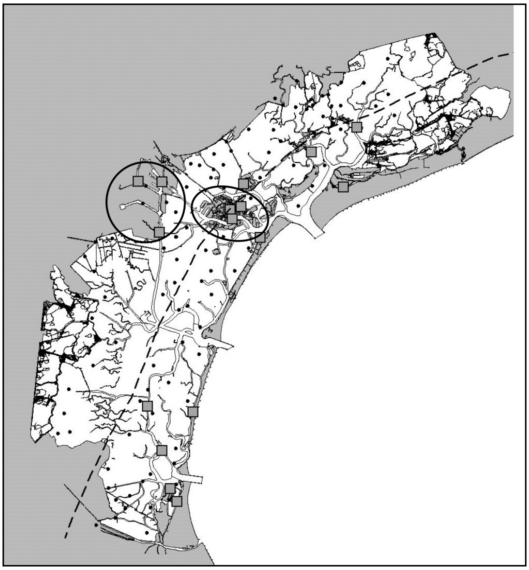


Figure 1: Map of Lagoon of Venice with locations of bottom sediment (dots) and water samples (squares). Dotted line subdivides inner (west) from outer (east) lagoon described in text. Circles indicate industrial area of Porto Marghera (left) and city of Venice (right). Sediment data derive from various papers[9,12,13]. Concentrations in waters comprise sets of monthly samplings performed by the Venice Water Authority in 16 stations[18].

Table 1 clearly shows that the industrial channels have maxima for all POPs, with values up to 3 orders of magnitude higher than background values. Data for the inner lagoon areas also show values 20-30 times higher than pre-industrial POP levels. The data for city canal sediments are comparable with industrial ones for PCB and with the inner lagoon for PCDD/F.

Table 1: Average values of PCB, PCDD/F (mass and toxicity equivalent) and HCB in sediments of Lagoon of Venice, subdivided by zone (see Fig. 1). Background (pre-industrial) values derived from dated cores collected inside Lagoon[16] are also shown.

Zone	PCBs µg kg^{-1}	PCDD/F µg kg^{-1}	I-TE ng kg^{-1}	HCB µg kg^{-1}
Industrial channels	810	14.0	300	260
Inner lagoon	26	1.0	16	2
Outer lagoon	5	0.3	4.0	0.2
City canals	600	0.5	6.0	nd
Background	*1*	*0.03*	*0.5*	*0.1*

The map of the enrichment values in sediments highlights areas which may be considered "hot spots" due to enriched contents of a suite of POPs.

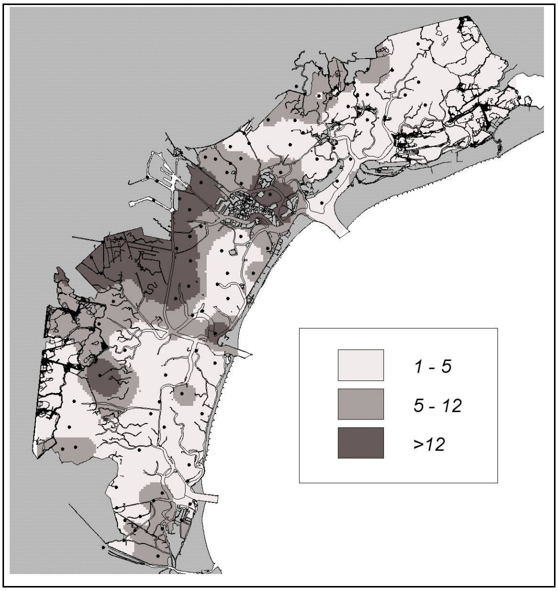


Figure 2: Map of values of enrichment factors, calculated by summing ratio of surface sediment values of PCB, PCDD/F and HCB, divided by respective background values.

Water concentrations

Water samples collected during 2001 in sixteen different stations in the Lagoon also showed that average POP values were much higher around the industrial area compared with the rest of the Lagoon. High values were also found in the city canals. Most of the PCDD/F values were higher than the threshold limit value established by the Italian Ministry of the Environment of 0.013 pgTE l^{-1} [18].

Table 2: Average values of PCB, PCDD/F and HCB in water samples collected in the Lagoon, subdivided by zone.

Zone	PCBs ng l^{-1}	PCDD/F pg l^{-1}	I-TE pg l^{-1}	HCB ng l^{-1}
Industrial channels	2.1	17	0.36	0.27
Lagoon	0.3	2	0.05	0.03
City canals	2.6	12	0.26	0.09

Atmospheric deposition fluxes

Rossini et al. (2004)[19] have shown that the variability in the mean bulk deposition fluxes of POPs among sampling stations observed over a two-year period (2002-2003) is clearcut (Table 3). As may be seen, mean daily fluxes of all organic pollutants were one to two orders of magnitude higher in stations in the industrial area than in the others. In particular, differences between “industrial”, “urban” and “lagoonal” sites were evident, at least for periods when all stations were operating (March-December 2003).

Table 3: Mean bulk deposition fluxes of POPs observed during 2002-2003 in the Venice area.

	PCBs pg m^{-2} d^{-1}	PCDD/F pg m^{-2} d^{-1}	I-TE pg m^{-2} d^{-1}	HCB pg m^{-2} d^{-1}
Industrial area	13669	278	6.5	2297
Inner lagoon	1482	30	0.9	435
Outer lagoon	546	31	1.4	341
City of Venice	1348	35	0.8	247

Daily intake

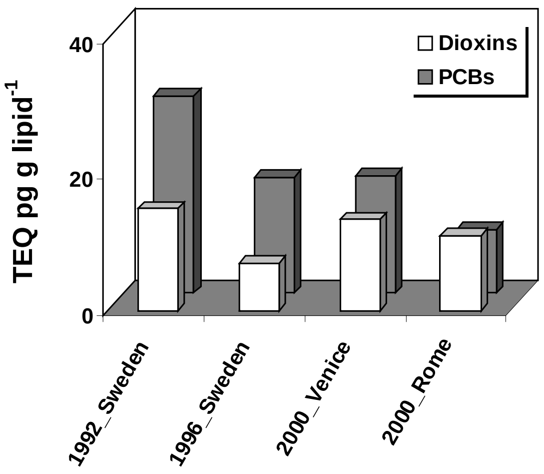
The Committee of Experts on Food of the European Commission has proposed a dose called 'Tolerable Daily Intake' (TDI), given the total of dioxin and PCB, equal to an average of 2 pg per day per kg of body weight, on a weekly basis. Recent data indicate that Venetians who eat local fish at maximum measured concentrations at typical consumption rates may exceed the current TDI and that high intake levels for specific seafood groups could elevate exposure further up to 5 pg TEQ kg bw^{-1} day^{-1} [6].

Risk assessment concerning human health may be found in the Progetto Orizzonte 2023, E-C sections[20], a study carried out in accordance with international recommended procedures[21,22], which described the main contamination pathways. The standard risk (avg. consumers and avg. concentrations in food) due to POPs was 3.7 cases per 10,000 inhabitants, rising in the worst case (high consumption and high concentrations) to 3.6 cases per 1,000 inhabitants. These figures are several times higher than that recommended by USEPA.

It is important to bear in mind that PCB toxicity must also be taken into account[23,24], and that the inclusion of HCB in the TEF approach for assessing health hazards, as recently proposed by Van Birgelen, is reasonable from the toxicological point of view[25,26].

Recent data of dioxin and PCB in the breast milk of mothers living in Venice and Rome show that the values (PCDD/F + PCB) were ~31 pgWHO-TE g $lipid^{-1}$ for Venice, compared with ~20 pgWHO-TE g $lipid^{-1}$ for Rome[27]. These figures are higher than data for 1996 in Sweden[28] (see Fig. 3). A preliminary work on dioxin and PCB contents in human serum of high- and low-fish consumers in Venice highlighted significant differences, with values (PCDD/F + PCB) of 53 and 27 pgWHO-TE g $lipid^{-1}$ respectively (unpublished data).

Figure 3: Average contents (pg TEQ g $lipid^{-1}$) in breast milk of women from Venice and Rome[27], compared with data from Sweden[28].



Conclusions

It is clear from most of the data published until now that the industrial area of Venice and the lagoon facing it are the parts of the basin which are most highly polluted by POPs. Here we find POP values in sediments one to two orders of magnitude higher than background values, and the whole central part of the Lagoon contains more than 10 times pre-industrial levels. POP values of water collected in the Lagoon and atmospheric deposition fluxes showed the same trends.
Assessment of the environmental and ecosystem risk (including risks to humans) still lacks the threshold values of the effects of PCDD/F and PCBs[29]. Thus, a complete analysis of ecological risk necessitates further investigations aimed at evaluating whether adverse effects could actually take place, given the current level of contamination.
It is therefore important to verify if signs of higher levels of these pollutants in the breast milk of Venetian mothers compared with Roman ones, as well as higher serum concentrations of TEQ PCB and dioxin in men with high consumption of fish from the Lagoon, are sufficient to ask for checks to be made, in order to create a 'network' which will oblige the health authorities to intervene.
The conclusions are that there is a clearcut need for constant monitoring in the Lagoon of Venice, so that this fragile ecosystem, which has succeeded in cohabiting with man for over a thousand years, can gradually heal the wounds it has suffered thanks to human activity, and can be safeguarded from the further threat of pollution. Monitoring is indispensable, so that appropriate information about risks for people's health and well-being can be made available.

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