ECOLOGICAL RISK ASSESSMENT OF ORGANOCHLORINE CONTAMINATION IN SEDIMENT FROM NAVIGATION CHANNELS AT PORTO MARGHERA, VENICE, ITALY

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Introduction

Porto Marghera is located 4 km north west of the historic city of Venice and adjacent to the city of Mestre (Figure 1). The Port of Venice located at Porto Marghera is the largest commercial shipping port in Italy and one of the largest ports in the Mediterranean Sea. The Venice Port Authority is responsible for maintaining the main navigation channel, Canale Malamocco Marghera, and other port navigation channels to 12 m depths. The channels are dredged periodically and the material managed according to a three-tier numerical sediment classification scheme prepared in 1993 by Minister of the Environment [1].

Several recent sediment and biota monitoring studies indicate that portions of the Venice Lagoon ecosystem have been adversely affected by eutrophication and chemical pollution from several point and nonpoint sources, including the rapidly expanding industrial district at Porto Marghera [2,3,4]. The results of an ecological risk assessment (ERA) by Wenning et al. [5] indicated that PCDD/F levels in Lagoon sediments were comparable to the levels found in undeveloped coastal environments. The results also indicated a limited potential for adverse effects on aquatic wildlife; however, contamination in the Lagoon was not homogenous, and at least one "hot spot" was identified at Porto Marghera, where PCDD/F levels in sediment at a few locations approached the levels found in ports located in Europe and the United States.

The President of the Italian Council of Ministers has designated the Venice Port Authority and the Venetian Water Authority (Magistrato alle Acque di Venezia) as the institutions responsible for characterisation and remediation of the sediment in navigation channels at Porto Marghera [13]. In response to this requirement, the Venice Port Authority and Venetian Water Authority have initiated a series of sediment assessments, biological studies and engineering reviews to understand current environmental conditions and formulate an action plan to meet the Council's goals[6]. As part of these efforts, an ERA was performed to evaluate the possible effects of different sediment management options on aquatic life in the Lagoon. This paper describes the results of the ERA involving dioxins, PCBs, hexachlorobenzene, and organochlorine pesticides. Using environmental chemistry data collected from navigation channel sediment during the past 5 years, food web modelling was performed to predict theoretical effects on indigenous avian and small mammal receptors exposed to organochlorines in surficial sediment and dredged material from the navigation channels at Porto Marghera.

Environmental Data and ERA Methods

The compilation of organochlorine chemistry and physical measurements of navigation channel sediments was completed by the Venice Port Authority and the Venetian Water Authority in 1999.

A summary of the data is presented in Table 1. The sediment database currently consists of 306 records representing 196 sampling locations. Chemistry analyses were performed using analytical procedures specified by the Ministero dell'Ambiente [1].

Table 1. Summary of PCDD, PCDF, PCB, DDT, hexachlorobenzene, and total organochlorine pesticide concentrations (ug/kg d.w.) in surficial sediment and dredged material collected from navigation channels at Porto Marghera, Venice, Italy.

Chemical [a]	No. Samples Analyzed	No. Samples > Detection Limit	Mean Concentration	95% UCL
Surface Sediment (0 – 50 cm)				
2,3,7,8-TCDD	30	23	1.23E-03	1.86E-03
Total PCDDs	33	19	3.65E-01	5.79E-01
Total PCDFs	33	19	1.76E+00	2.57E+00
2,3,7,8-TCDD TEQs	33	19	2.13E+00	3.12E+00
Total PCBs	132	132	5.37E+03	7.42E+03
Total DDT	37	9	2.57E+00	2.84E+00
Total OC Pesticides	32	28	6.61E+02	8.96E+02
Hexachlorobenzene	42	28	1.36E+02	2.09E+02
Dredged Sediment Material (0 – 3 m)				
2,3,7,8-TCDD	40	28	1.38E-03	2.13E-03
Total PCDDs	43	43	4.69E-01	7.51E-01
Total PCDFs	43	43	2.30E+00	3.56E+00
2,3,7,8-TCDD TEQs	43	43	2.77E+00	4.30E+00
Total PCBs	17	17	8.11E+01	1.44E+02
Total DDT	56	9	2.54E+00	2.72E+00
Total OC Pesticides	51	37	5.47E+02	7.16E+02
Hexachlorobenzene	48	46	1.25E+02	1.90E+02

a. Total PCBs, PCDDs, and PCDFs are reported as 2,3,7,8-TCDD equivalents (TEQs) using Van den Berg et al. [7] toxicity equivalent factors.

The ERA was performed in accordance with guidelines developed by the U.S. Environmental Protection Agency (USEPA) [8,9,10]. Aquatic bird and small mammal receptors of interest (ROIs) were selected to represent maximally exposed or sensitive species in two aquatic feeding guilds: fish-eaters (piscivores) and aquatic invertebrate-eaters (invertivores). Wildlife ROI exposures were estimated by calculating an average daily dose (ADD). Wildlife ADDs were calculated based on incidental ingestion of sediment and consumption of prey. Wildlife ADDs were calculated using the 95% upper confidence limit concentrations in sediment and prey, and receptor-specific exposure parameters. The wildlife ADD for a given chemical represents the amount that an organism might ingest if that organism foraged exclusively in Porto Marghera. The effects assessment and risk characterization for wildlife were conducted using predicted prey concentrations expressed as dioxin TEQs, total PCBs, total DDT, and HCB. The results were compared to appropriate chronic no-observed-adverse-effect-level (NOAEL) and lowest-observed-adverse-effect-level (LOAEL) wildlife toxicological reference values (TRVs) [11,12]. For fish and aquatic invertebrates, predicted body burdens were compared to chronic and acute no

effect critical body residue values (CBRs) reported in the literature.

Results & Conclusions

The profile of organochlorine contamination in navigation channel sediment is not homogenous and indicates the presence of contamination hot spots in areas of historical chemical storage and manufacturing activities within the Port. The majority of the contamination occurs at depth, suggesting that current source control measures have been effective in reducing or eliminating releases to the Lagoon. In general, the concentrations of hexachlorobenzene, total PCBs, total PCDDs, and total PCDFs are a high concern to the benthic invertebrate community because the 95% UCL concentration exceeded the U.S. sediment toxicity effect benchmarks (ERM, PEL, AET, or EqP) used in the ERA. Total DDT poses a low-to-moderate concern because the 95% UCL concentration exceeds the ERL, TEL, or EqP-1% benchmarks but is below the ERM, PEL, AET, or EqP-4% benchmarks.

Predicted wildlife ADDs and hazard quotients (HQs) for aquatic biota and wildlife receptors are summarized in Table 2. Exposures to chemicals in sediment that result in HQs less than one are unlikely to cause adverse effects to wildlife; in contrast, HQs greater than one indicate that adverse effects are possible, if the different exposure and toxicity assumptions used in the ERA are met. With HQs less than 2, total DDT, organochlorine pesticides, and hexachlorobenzene in sediment are unlikely to pose a risk to wildlife. The higher HQs for total PCB, total PCDDs, and total PCDFs are of more concern. The theoretical exposure of ROIs to 2,3,7,8-TCDD TEQs in surficial sediment and dredged material at some locations may result in an adverse effects to these receptors, given the highly bioaccumulative nature of these compounds and the conservatism of the risk model.

Table 2. Hazard quotients (HQs) [a] associated with exposure to organochlorines in surficial sediment and dredged material in Porto Marghera navigation channels.

Chemical [a]	Piscivorous Receptors		Invertivorous Receptors	
	Little Tern	Polecat	Snowy Plover	Water Vole
Surface Sediment (0 – 50 cm)				
2,3,7,8-TCDD TEQs	3.6	30	3.3	18
Total PCBs	3.8	206	1.1	38
Total DDT	5.5	0.01	1.4	0.002
Total OC Pesticides	0.3	0.02	0.2	0.03
Hexachlorobenzene	0.2	2	0.05	0.4
Dredged Sediment Material (0 – 3 m)				
2,3,7,8-TCDD TEQs	91	772	84	453
Total PCBs	1.3	70	0.4	13
Total DDT	1.6	0.003	0.4	0.001
Total OC Pesticides	0.4	0.05	0.5	0.07
Hexachlorobenzene	0.2	2.3	0.1	0.4

a. HQs represent the sum of sediment and prey ingestion, and assumes receptors forages exclusively in Porto Marghera navigation channels.

The results of the ERA suggest that contamination in surficial sediments at some locations may pose an adverse effect on certain aquatic wildlife that forage on prey exposed to 2,3,7,8-TCDD TEQs and PCBs in the top 50cm of sediment. Hexachlorobenzene, total DDT, and organochlorine pesticides do not pose a significant threat to wildlife in surface sediment or dredged material. With the exception of PCDD/Fs, wildlife HQs were generally higher from exposure to surficial sediment than buried sediment (0 – 3 m depth). With regard to the management of dredged material, the current Venetian sediment classification method could be modified for organochlorines to be more protective of aquatic wildlife. However, the results of Tier III sediment toxicity and bioaccumulation testing do not support the need for significant changes to the current numeric criteria. As the environmental cleanup plan for the Porto Marghera area proceeds, future work will focus on expanding scientific knowledge of the Port's impacts on the Venice Lagoon, and exploring engineering solutions for appropriate future removal, treatment, and disposal of dredged material.

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