VENICE LAGOON: WORKS TO BE DONE REGARDING THE BED OF THE INDUSTRIAL BRENTELLA CANAL AND TO MAKE IT SAFE

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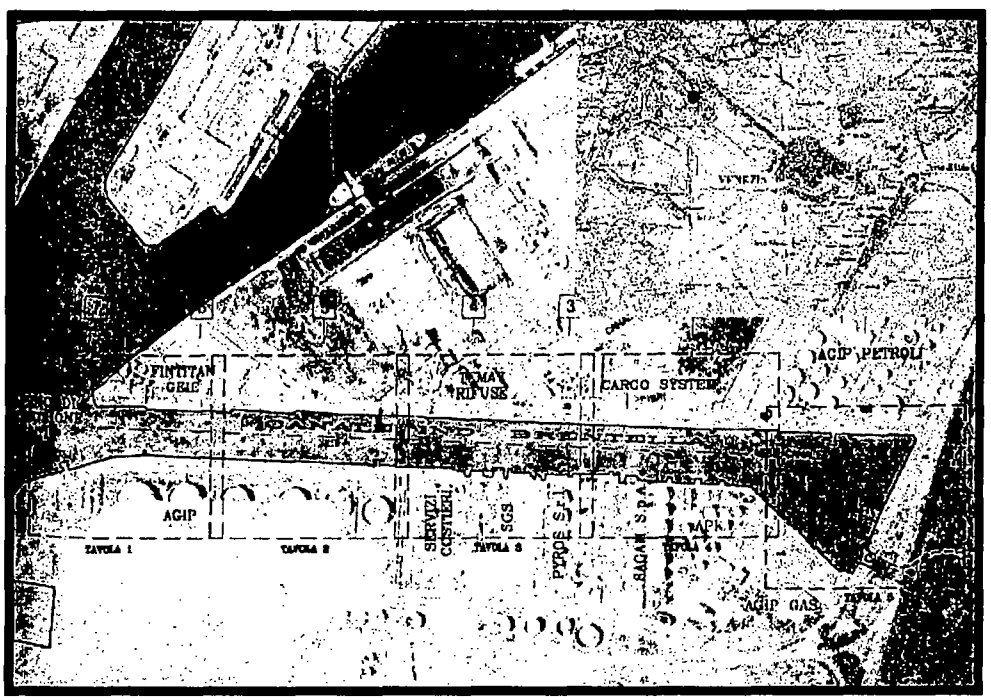
Introduction

Development was started on the first industrial area of Porto Marghera at the beginning of the 1900s along the northern bank of the Venice Lagoon, with the occupation of mire and sandbanks and the construction of industrial and commercial canals along whose banks you mainly found petrol, coal and metal production plants.

Monitoring of the state of pollution of the Venice Lagoon started at the end of the '90s, also in relation to different industrial activities that had, over time, been partly abandoned and integrated by new activities, mainly petrochemical and ship building [1].

And this is where the problem to remediate the Industrial Brentella Canal environment actually begins, located inside the Venice Lagoon (Fig. 1).

Fig. 1 – Venice Lagoon: Industrial Brentella Canal location



Field and laboratory data brought to light the presence of a continuous layer of mud on the bottom, not very consistent, approximately 2 m thick and seriously contaminated by PCDD and PCDF, PAH and heavy toxic metals (Tab. 1), the Consorzio Venezia Nuova, assigned by the

Magistrate of the Venice Waterways, and with the co-operation of qualified experts in this sector, drew up a feasibility study with the aim of tidying up and making the Brentella Canal bed safe.

The project proposed is based on the principle of isolating the causes of such negative impacts on the surrounding environment and on human life, preventing the highly toxic pollutants from spreading. With reference to Fig. 2, the work that needs doing is to keep the hazardous substances from spreading in all directions by using suitable barriers.

The work involving tidying up of the canal bed will be carried out without water, dividing the canal into three consecutive sections which will make it possible to monitor the mud when working and hence to identify any particularly contaminated areas that need removing and subjecting to a specific treatment.

Methods and materials

The Brentella canal is north of the Porto Marghera industrial area and extends from north to south in a straight line (Fig. 1). The canal is about 1,300 metres long and, on an average, 80 metres wide, widening to 90 metres at the dock. Its average depth, close to the axis, is about 7 metres.

In view of the work to stop and reverse deterioration of the Venice Lagoon, in 1999 the Brentella canal was subject to a chemical-physical-geological survey entailing a series of samples and analyses of the canal's bed, the water and the banks, as well as tests to determine fitness for biological habitation [2]. Basically six thrust drillings were made at a depth of –10.5 m below sea level along the Brentella Canal's central axis, involving an average thickness of 2.8 metres of sediment. A sample was taken from three drillings every 50 cm of soil and all the established analytical tests were carried out on each sample as established by current standards [3], obtaining a detailed vertical distribution of the pollutant concentrations. On the 3 remaining drillings, the same was done on thicker soil samples (approx. 2.5 m).

The main evidence found as regards the condition of the Brentella Canal bed is the following:

Tab 1 – Organic and inorganic pollutants (mg/Kg ss and μ/Kg for TEQ) concentration in the mud layers.

	Drilling	As	Cd	Cr	Hg	Ni	Pb	Cu	Zn	Pesticides	PCB	PAH	Total Hydroc.	PCDD/F TEQ
Surface Layer	12	77	40	36	10	24	274	201	2737	0,008	0,22	99	620	0,81
	15	179	33	47	6	23	574	773	3604	0,033	0,85	293	870	1,17
	17	89	28	47	5	34	429	454	3588	0,006	0,52	33	293	1,1
Deep Layer	12	219	93	49	17	22	927	887	5838	0,018	0,31	215	1905	3,18
	15	1213	76	166	12	16	3589	3333	10324	0,057	1,26	238	2080	12,59
	17	984	76	179	8	22	3216	3281	14426	0,089	1,76	64	475	19,06
Sediments	12	8	<0,5	9	<0,1	13	18	16	41	<0,001	<0,01	1	10	0,002
	15	14	<0,5	12	0,1	15	19	17	44	<0,001	<0,01	1	10	0,003
	17	13	<0,5	11	0,1	17	15	17	48	<0,001	<0,01	1	10	0,012

- a continuous layer of a slimy-clayey material was found, about 2 metres thick, seriously contaminated by PCDD, PCDF, HC, PAH and heavy toxic metals (Cd, As, Pb, Cu, Cr) making it a dangerous environmental hazard. With reference to Tab. 1 there are two continuous horizons inside this layer with different concentrations: the most highly polluted layer is the one located between -8 and -9 metres below sea level, that is, about 1-5 m below the top of the bed. The

concentrations of PCDD in particular are among the highest ever recorded in port sediments (up to 28 ug/kg ss).
- the underlying soil is not contaminated, sign of a low vertical migration.
- there is absolutely no sign of life in the sediments, sign of the presence of powerful biological inhibitors, but also of a low risk of transfer of the pollutant to the food chain.
- the information gleaned from the biological tests conducted on colonies of mussels planted in the Brentella canal have proved that local pollution can lead to genetic alterations on living species [(2)].

On the basis of this knowledge and because of the need to put a stop to this environmental threat and to restore draughts compatible with navigability, four alternative projects have been studied [(4)]:

- made safe (capping)
- on site treatment
- removal and transfer to a dump
- removal and specific treatment

Having considered the type and concentrations of pollutants in the Brentella bed, the relevant mass of contaminated mud (equivalent to about 300,000 m3) and the secondary pollution risks, besides the costs for moving such a quantity, the solution to make the Brentella safe, once and for all, has been opted for.

Making the canal safe means that suitable barriers must be found and/or made that will prevent the exchange of substances between the canal bed and the surrounding environment. The permanent separation of the polluted materials from the surrounding environment can be achieved in the following way (Fig. 2):

Fig 2 – Canal section: Potential dispersion of the pollutants.

1. with a perimeter enclosure to prevent horizontal spreading, made with 1.20-metre thick reinforced concrete diaphragms down to a depth of –22 metres below sea level, going through a variegated stratigraphy which includes embankment soil, the "caranto" and a succession of clayey silts and silty sands, until it comes up against the impermeable layer as at the next point 3;
2. summit capping to prevent the flow of pollutants from spreading from the bed to the water of the overhead canal, realised with a multilayer cover guaranteeing hermetic sealing, high mechanical strength and ready for the reconstruction of an ideal habitat for the benthonic species;
3. downward sealing will, instead, be entrusted to the continuous silty clayey layer, whose impermeable properties are such to provide a guarantee of reliability and stability over time . This layer is about –16 m below sea level and approximately 2 m thick.

This work will be carried out dividing the canal into three sections so the bed can be dried: this will make it possible to preload the bed itself with coarse material that will cause the level of the bed to drop about 0.5 m, important for navigability reasons, and to reduce water porosity to achieve improved stabilisation of the polluted mud and, consequently, a reduction in contaminant

mobility. By working on a dry bed, surveys can be carried out directly on site while working in order to locate any particularly polluted patches of material so they can be removed and treated.

Results and discussion

For the works to save the Venice Lagoon environment, the industrial Brentella canal has been subjected to a chemical, physical and geological survey the results of which have brought to light serious environmental deterioration due to the presence of very high concentrations of dioxins and heavy toxic metals.

Local authorities have, therefore, declared the urgent need for a project to remediate the Brentella canal. The solution opted for consists in making the canal definitively safe by means of summit capping and a perimeter enclosure with diaphragms in reinforced concrete and on-site stabilisation of the mud.

The following results will be obtained with this technology:

- the exchange of substances between the canal bed and the surrounding area is prevented.
- the eco-compatible conditions will be restored, safe, that is, from an environmental and man's health point of view.
- the canal can again be navigated, restoring the level of the water to be compatible with Port Authorities' uses.
- risks connected to any work that entails moving bed materials are eliminated.
- costs and times are reduced compared to the other solutions taken into consideration, such as the off-site treatment of the mud in specific combustion plants, the deposit in suitable, authorised dumps, rendering inert on-site without summit capping.

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