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Data Article

Dataset for the assessment of selected POP's pollution and effectiveness of environmental policies in the Bắc Giang Province and Cầu River (Northern Vietnam)

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ABSTRACT

This data article presents the datasets obtained during the years 2011–2012 in the Provinces of Bắc Giang and Bắc Ninh (Northern Vietnam) in the framework of an International Cooperation project aimed at the restoration and preservation of natural resources together with the improvement of life conditions of the local population. All information relative to sampling strategy, location and description of the studied sites are reported, together with analytical data (*i.e.* grain size, Total Organic Carbon, Organic Nitrogen, C/N ratio, $\delta^{13}C$, PolyChlorinated Biphenyls, Polycyclic Aromatic Hydrocarbons, PolyBrominated Diphenyls Ethers, PolyChlorinated Dibenzo-p-Dioxins and Furans, OrganoChlorine Pesticides, Total Petroleum Hydrocarbons). In addition, maximum admitted levels, quality standards and emission limits set by the Vietnamese environmental regulations are reported in comparison

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to Italian ones for the following parameters and environmental compartments: noise, soils, air, drinking and groundwaters, sediments. Interpretation of this dataset is fully discussed in Giuliani *et al.* (2019) [1].

Specifications Table

Subject area	*16. Environmental Science*
More specific subject area	*16.3 Environmental Chemistry* *16.8 Management, Monitoring, Policy and Law*
Type of data	*Tables, text file, figures*
How data was acquired	*Mechanical sieving, Fisons NA2000 Elemental Analyzer, Agilent Technologies 7890A Gas Chromatograph coupled with Agilent Technologies 5975C quadrupole Mass Spectrometer, Agilent Technologies 6890 Series Gas Chromatograph coupled with Thermo Finnigan MAT 95 XP double-focusing High-Resolution Mass Spectrometer, Thermo Scientific DSQ™ II Series single quadrupole GC-MS, National Technical Regulations of Vietnam, Italian Legislative Decrees and Decrees of the Italian Prime Minister*
Data format	*Raw*
Experimental factors	*Soils and sediments were collected by grab or manually, kept frozen until the arrival at the laboratory, freeze-dried and then homogenized before the analysis*
Experimental features	*Samples were separated in different aliquots and subjected to the analytical investigations described in Giuliani* et al. *(2019) "When Research meets NGOs: the GVC-UCODEP project in the Bắc Giang Province and Cầu River (Northern Vietnam) and its feedback on national monitoring programs"* [1]
Data source location	*Bắc Giang and Bắc Ninh Provinces (Northern Vietnam): 21°07′ − 21°18′ Lat. N, 105°55′ − 106°02′ Long. E*
Data accessibility	*All data are presented in the paper*
Related research article	*This data article is submitted as a companion paper to the research article by Giuliani* et al. *(2019) "When Research meets NGOs: the GVC-UCODEP project in the Bắc Giang Province and Cầu River (Northern Vietnam) and its feedback on national monitoring programs", Environmental Science & Policy, 101, 279–290*

Value of the Data

- This dataset is useful because the Bắc Giang Province is one of the areas most affected by the consequences of rapid population growth and not completely controlled development of Vietnam.
- Local populations will greatly benefit from these datasets as they evidenced the presence of specific pollution/law issues that need to be better addressed.
- The methodological approach presented could be used for further insights and development of experiments, inspiring similar actions in other fast-growing countries.
- As additional value, the project's results have evidenced the potential for a positive and effective collaboration between research, local institutions and NGOs.

1. Data description

This data article presents the list of the samples (with coordinates and description, Table 1) studied in the framework of the International Cooperation GVC-UCODEP project "Promotion of environmental

Table 1
List of the studied samples with coordinates and description. Geographical location is presented in [1].

Sample	Lat. N	Long. E	Description
1	21° 14.755′	106° 06.194′	Soil from a puddle
2	21° 14.750′	106° 06.172′	Sediment from a drainage basin
3	21° 12.729′	106° 02.150′	Soil from a puddle close to the Cầu river
4	21° 12.729′	106° 02.150′	Sediment from the Cầu River
5	21° 14.627′	106° 02.294′	Sediment retrieved from a family well
6	21° 13.399′	106° 02.181′	Sediment from rice fields close to a water purifier
7	21° 14.286′	106° 02.395′	Sediment from a pond
8	21° 11.027′	106° 10.920′	Sediment retrieved from a family well
9	21° 10.999′	106° 10.217′	Sediment from the Cầu River
10	21° 11.110′	106° 10.261′	Soil from a field close to brick factories
11	21° 15.098′	106° 06.287′	Sediment retrieved from a family well
12	21° 09.981′	106° 14.118′	Soil from the Cầu River banks
13	21° 10.238′	106° 13.941′	Sediment retrieved from a family well
14	21° 11.100′	106° 14.461′	Sediment retrieved from the bridge in a river basin
15	21° 10.350′	106° 15.293′	Sediment from the Cầu River
16	21° 10.325′	106° 15.304′	Soil from a flooding field
17	21° 10.384′	106° 15.440′	Sediment retrieved from a family well
18	21° 10.999′	106° 15.393′	Soil from a rice field
19	21° 12.173′	106° 06.194′	Exposed sediment from the Cầu River banks
20	21° 12.247′	106° 06.780′	Sediments close to the pumping stations of the Cầu River hydraulic system
21	21° 12.681′	106° 12.681′	Sediments close to the pumping stations of the Cầu River hydraulic system
22	21° 12.681′	106° 02.504′	Sediments from the Cầu River, east of the Vân Ha peninsula
23	21° 12.681′	106° 02.504′	Sediments from the Cầu River, east of the Vân Ha peninsula
24	21° 14.501′	106° 10.512′	Sediment from the discharge of a paper factory (collected from the bridge)
25	21° 14.387′	106° 13.270′	Sediment from the discharge of a paper factory (collected in a pond)
26	21° 14.866′	106° 10.200′	Sediment from a collector canal of the industrial zone
27	21° 07.219′	105° 55.908′	Sediment from the Ngũ Huyện Khê River close to a village devoted to metal manufacturing
28	21° 10.423′	106° 02.150′	Sediment from the Ngũ Huyện Khê River close to a village devoted to paper production/manufacturing
29	21°16.670′	106°11.125′	Sediment from the Thương River upstream of Bắc Giang City
30	21°18.002′	106°11.736′	Sediment from the Thương River downstream of Bắc Giang City

Fig. 1. Pictures of A) sampling operations (from left to right: grab sampling from a bridge, sample collection, and manual sampling), and B) sampling areas (from left to right: pumping station of the Cầu River hydraulic system in Quang Châu, exposed sediment from the Cầu River banks in Quang Châu, collector canal of the Song Khê - Nội Hoàng industrial zone).

Table 2
Grain size composition (as % of fines and sand), Total Organic Carbon (TOC; %), Organic Nitrogen (ON; %), C/N ratio and $\delta^{13}C$ (‰) in the studied sites. Interpretation is fully provided in [1].

	Site													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fines	84	53	72	92	44	88	85	72	75	79	62	61	29	62
Sand	16	47	28	8	56	12	15	28	25	21	38	39	71	38
TOC	8.1	0.62	1.9	2.5	0.79	1.5	4.5	n.d.	0.83	0.70	2.2	1.4	2.0	1.7
ON	0.79	0.076	0.19	0.22	0.087	0.16	0.58	n.d.	0.081	0.0735	0.25	0.13	0.21	0.14
C/N	12	11	13	14	12	12	8.9	n.d.	12	15	11	13	11	15
$\delta^{13}C$	−25.3	−24.9	−26.8	−26.8	−27.2	−23.9	−23.6	n.d.	−25.8	−21.6	−26.8	−20.0	−26.6	−26.5

n.d. = not determined.

Table 3
List of the ^{13}C-labeled compounds used as internal quantification standards for PolyChlorinated Biphenyls (PCBs), Polycyclic Aromatic Hydrocarbons (PAHs), PolyBrominated Diphenyls Ethers (PBDEs) and PolyChlorinated Dibenzo-p-Dioxins and Furans (PCDD/Fs), and surrogate compound used as internal quantification standards for OrganoChlorine Pesticides (OCPs) and Total Petroleum Hydrocarbons (TPHs) $C_{>12}$. Further details are provided in [1].

^{13}C PCBs	PCB-3; PCB-15; PCB-28; PCB-52; PCB-77; PCB-81; PCB-105; PCB-114; PCB-118; PCB-123; PCB-126; PCB-153; PCB-156; PCB-157; PCB-167; PCB-169; PCB-180; PCB-189; PCB-194; PCB-208; PCB-209
^{13}C PAHs	Acenaphthylene; Benzo [*a*]pyrene; Phenanthrene
^{13}C PBDEs	BDE-28; BDE-47; BDE-99; BDE-100; BDE-153; BDE-154; BDE-183; BDE-209
^{13}C PCDD/Fs	2,3,7,8-TCDD; 2,3,7,8-TCDF; 1,2,3,7,8-PeCDD; 1,2,3,7,8-PeCDF; 2,3,4,7,8-PeCDF; 1,2,3,4,7,8-HxCDD; 1,2,3,6,7,8-HxCDD; 1,2,3,4,7,8-HxCDF; 1,2,3,6,7,8-HxCDF; 1,2,3,7,8,9-HxCDF; 2,3,4,6,7,8-HxCDF; 1,2,3,4,6,7,8-HpCDD; 1,2,3,4,6,7,8-HpCDF; 1,2,3,4,7,8,9-HpCDF; OCDD
OCPs	Pentachloronitrobenzene
TPHs $C_{>12}$	5α-Androstane

protection in the Việt Yên, Yên Dũng and Hiệp Hòa districts in the Bắc Giang Province, Vietnam", together with a collection of pictures representing sampling operations and areas (Fig. 1). Raw data of grain size, Total Organic Carbon (TOC), Organic Nitrogen (ON), C/N ratio, $\delta^{13}C$ are presented in Table 2. Table 3 lists the ^{13}C-labeled or surrogate compounds used as internal quantification standards for the measurements of POPs. Tables 4–9 report data relative to each specific class of POPs: Table 4 for PolyChlorinated Biphenyls (PCBs), Table 5 for Polycyclic Aromatic Hydrocarbons (PAHs), Table 6 for PolyBrominated Diphenyls Ethers (PBDEs), Table 7 for PolyChlorinated Dibenzo-p-Dioxins and Furans (PCDD/Fs), Table 8 for OrganoChlorine Pesticides (OCPs), and Table 9 for Total Petroleum Hydrocarbons (TPHs). Total PAH concentrations are also normalized for a TOC % content of 1 [2]. Total PCDD/F concentrations are expressed also as pg g^{-1} I-TEQ (International Toxic Equivalent), calculated using the International Toxicity Equivalence Factors (I-TEFs) defined by Van den Berg *et al.* [3]. As part of the project's strategy, enforced Vietnamese regulations were studied to check their effectiveness in protecting the population and the environment. For this reason, maximum admitted levels, quality standards and emission limits set by the Vietnamese environmental regulations relative to noise (maximum admitted levels in Table 10), soils (quality standards in Table 11), air (quality standards in Table 12, emission limits in Table 13), drinking and groundwaters (quality standards in Table 14), and sediments (quality standards in Table 15) are reported in comparison to Italian ones.

2. Experimental design, materials, and methods

Sampling campaigns were realized in 2011 and 2012 and some stations of the 2011 survey were sampled again in 2012 in order to perform the analyses for PCDD/Fs (Table 7).

Soil and sediment samples were taken at rivers, rice fields, sewages, collector canals, pounds, puddles and family wells (Table 1) in the Provinces of Bắc Giang and Bắc Ninh (Northern Vietnam). The

Site															
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
88	37	0.98	51	70	81	99	63	59	32	94	88	41	31	53	82
12	63	99	49	30	19	1	37	41	68	6	12	59	69	47	18
1.9	0.66	0.079	1.5	2.3	1.2	1.3	1.6	n.d.	17	2.8	1.1	0.85	16	1.3	13
0.15	0.031	0.011	0.14	0.12	0.13	0.13	0.13	0.31	0.60	0.19	0.12	0.11	0.78	0.13	0.22
16	38	20	13	28	14	12	34	n.d.	36	20	11	10	25	13	64
−24.8	−27.0	−25.4	−24.4	−23.8	−23.3	−26.9	−26.1	n.d.	−24.3	−26.1	−23.4	−24.0	−21.4	−24.8	−23.2

2011 sampling campaign was focused on the identification of contaminant levels in areas not influenced by direct sources. On the contrary, the second sampling campaign in 2012 was focused on those areas where inputs from industrial, urban and specific manufacturing activities were identified.

Samples were taken by grab sampling or *via* manual collection (Fig. 1). They were kept frozen until the arrival at the laboratory, and then freeze-dried and homogenized before the analysis.

Grain size analyses were carried out by wet mechanical sieving at 63 μm to separate sands from fine particles, after a pre-treatment with H_2O_2. TOC, $\delta^{13}C$, and ON were determined with an Elemental Analyzer after carbonate elimination by acidification.

PCBs, PAHs, and PBDEs were determined with the same sample preparation protocol [1]. Automated instruments were used for analytes extraction and sample clean-up. After extraction and before clean-up, samples and blanks were spiked with a known amount of ^{13}C-labeled compounds mixtures (Table 3). Instrumental determinations were carried out with a quadrupole mass spectrometer (MS) operating in electron impact mode (EI, 70 eV), coupled with a gas chromatograph (GC). Acquisition was performed in Selected Ion Monitoring (SIM) mode. Quantification was performed using internal standards and the isotopic dilution technique. Results were corrected using the instrumental response factors and calculated on a dry weight basis (Tables 4–6). Precision was estimated as repeatability and the Relative Standard Deviation (RSD) was always below 10% for total PCBs, PAHs, and PBDEs. Accuracy was estimated through repeated analyses of Standard Reference Material (SRM) 1941b from the National Institute of Standards and Technology (NIST; PAHs, PCBs) and SRM SQC072 from RTC (PBDEs, PCBs). Results were always within the certified/reference analytical uncertainty.

PCDD/Fs were analyzed only in samples that presented either the highest concentrations of other POPs or peculiar environmental conditions. The analysis was performed through automated extraction and clean-up systems [1]. Quantification was finalized using internal standards and the isotopic dilution technique (Table 3) with a gas chromatograph coupled to a High-Resolution mass spectrometer operating in EI mode (45 eV; $R \geq 10{,}000$). Results were corrected using the instrumental response factors and calculated on a dry weight basis (Table 7). RSD was always below 10% for total PCDD/Fs. Accuracy was estimated through repeated analyses of SRM DX-1 from the National Water Research Institute. Results were always within the certified/reference analytical uncertainty.

Samples of the 2011 campaign were analyzed also for 20 OCPs (Table 8). Analyses were performed with GC–MS instruments in SIM mode [1]. Quantification was carried out *via* calibration curve, using an internal standard (Table 3), and calculated on a dry weight basis. RSD was always below 10% for total OCPs. Accuracy was estimated through repeated analyses of SRM 1941b from the NIST. Results were always within the certified/reference analytical uncertainty.

Samples of the 2012 campaign were analyzed also for TPHs (Table 9), with the same GC–MS system used for the OCP analyses. Quantification was carried out with an internal standard (Table 3). Acquisition was performed in SIM mode and results are reported on a dry weight basis. RSD was always below 10% for total TPHs. In absence of a SRM to check the recovery of TPHs, a clear marine sediment was spiked with a Diesel Range Organics (DRO) mixture and analyzed. Results showed a recovery percentage from 92 to 101.

Table 4

Concentrations (in pg g^{-1}) of PolyChlorinated Biphenyls (PCBs) as chlorination classes and total, indicators (iPCBs) and dioxin-like (DL-PCBs) congeners (expressed both as single compound and total), and non-Aroclor PCB-11 in the studied sites. The high level of Total Organic Carbon and the overall composition of site 28, hampered the reliable analyses of PCBs that were therefore not carried out. Interpretation is fully provided in [1].

PCBs	Site																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30
Chlorination classes																													
Cl-1	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Cl-2	1151	416	691	778	542	662	1126	1009	262	556	1117	470	813	691	809	324	<d.l.	657	802	1500	1067	1201	1688	1326	1039	841	1230	1751	1286
Cl-3	6102	2183	3043	8302	3378	4159	5404	6119	1110	4860	4875	3272	3421	4438	6934	3152	1877	4058	1146	1022	3603	1823	1715	<d.l.	1710	966	1779	2837	4437
Cl-4	5738	2414	3745	6115	2620	3063	5678	3470	849	3393	3090	3080	3371	2619	3290	2121	1111	2556	3887	976	2710	1688	1618	2477	1288	1072	3191	2084	6482
Cl-5	1814	790	1304	2039	678	969	2627	1098	460	997	1540	1090	1516	980	1833	575	332	794	8149	241	643	975	1491	1060	435	526	10,864	1792	8443
Cl-6	574	252	568	871	271	277	1109	388	205	239	861	521	869	359	758	240	172	287	3772	11	116	454	426	505	77	199	8853	1566	7008
Cl-7	83	23	32	110	49	49	131	44	47	10	289	44	144	62	115	35	31	42	315	32	50	117	71	195	70	73	1003	679	2630
Cl-8	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	6.3	0.10	15	8.5	1.9	12	5.6	93	114	302
Cl-9	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	5.9	<d.l.	<d.l.	<d.l.	<d.l.	6.1	8.1	<d.l.	<d.l.	<d.l.	<d.l.
Cl-10	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Σ_{127} PCBs (ng g^{-1})	**15.5**	**6.1**	**9.4**	**18.2**	**7.5**	**9.2**	**16.1**	**12.1**	**2.9**	**10.1**	**11.8**	**8.5**	**10.1**	**9.1**	**13.7**	**6.4**	**3.5**	**8.4**	**18.1**	**3.8**	**8.2**	**6.3**	**7.0**	**5.6**	**4.6**	**3.7**	**27.0**	**10.8**	**30.6**
Indicators																													
PCB-28	1540	867	1016	1949	729	804	1281	1294	229	1246	1230	752	890	723	1661	655	314	974	264	229	681	422	332	<d.l.	324	237	436	560	1012
PCB-52	1429	633	841	1123	576	848	1457	923	228	950	817	943	921	529	883	512	294	637	725	268	689	349	294	511	279	205	<d.l.	571	2233
PCB-101[a]	484	210	319	519	193	295	586	308	129	300	462	278	330	261	444	157	87	213	1351	62	172	205	301	253	117	115	1441	382	2003
PCB-118[b]	191	65	143	225	66	82	386	101	54	64	248	131	219	88	222	60	25	54	1687	15	34	135	195	109	27	63	2998	252	1045
PCB-138[c]	178	50	141	193	49	62	289	80	43	32	267	134	234	72	182	47	28	47	745	<d.l.	17	90	83	88	13	32	1752	318	1380
PCB-153	150	51	112	166	50	54	202	78	46	45	248	105	184	70	153	43	31	50	1079	5.0	24	124	132	119	15	54	2642	440	1860
PCB-180	37	15	32	41	18	17	35	12	18	10	89	25	42	18	33	11	10	12	103	5.6	16	45	23	41	13	14	314	205	675
Σ_7 iPCBs (ng g^{-1})	**4.0**	**1.9**	**2.6**	**4.2**	**1.7**	**2.2**	**4.2**	**2.8**	**0.75**	**2.6**	**3.4**	**2.4**	**2.8**	**1.8**	**3.6**	**1.5**	**0.79**	**2.0**	**6.0**	**0.58**	**1.6**	**1.4**	**1.4**	**1.1**	**0.79**	**0.72**	**9.6**	**2.7**	**10.2**
Dioxin-like congeners																													
PCB-77	<d.l.	<d.l.	30	91	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	77	<d.l.	<d.l.	<d.l.	41	<d.l.	<d.l.	<d.l.	44	<d.l.	<d.l.	1.6	6.8	<d.l.	1.4	<d.l.	71	<d.l.	<d.l.
PCB-81	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
PCB-105	94	29	68	100	25	30	191	48	15	22	93	66	104	34	85	21	12	21	849	11	<d.l.	56	168	46	8.3	28	1485	112	415
PCB-114	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	44	<d.l.	<d.l.	<d.l.	0.10	12	0.50	<d.l.	74	<d.l.	<d.l.
PCB-118[b]	191	65	143	225	66	82	386	101	54	64	248	131	219	88	222	60	25	54	1687	15	34	135	195	109	27	63	2998	252	1045
PCB-123	<d.l.	8.0	13	9.0	<d.l.	<d.l.	16	9.3	9.2	<d.l.	19	9.1	14	9.0	13	<d.l.	<d.l.	9.0	44	3.1	12	3.8	<d.l.	9.3	7.2	8.6	93	8.1	62
PCB-126	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	1.1	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	7.2	<d.l.	<d.l.
PCB-156	15	7.0	15	21	12	6.1	37	12	<d.l.	<d.l.	29	19	29	9.1	18	5.1	3.3	4.4	159	0.62	<d.l.	15	13	28	<d.l.	7.1	445	44	163
PCB-157	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	10	<d.l.	<d.l.	<d.l.	11	3.1	10	<d.l.	6.2	<d.l.	<d.l.	<d.l.	35	<d.l.	<d.l.	<d.l.	6.4	<d.l.	<d.l.	2.4	106	13	40
PCB-167	37	8.0	36	44	18	14	84	14	<d.l.	<d.l.	59	28	62	18	40	9.2	6.1	11	314	<d.l.	4.1	24	28	26	<d.l.	6.3	838	72	276
PCB-169	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	10	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	2.7	2.4	2.6	35	<d.l.	<d.l.	<d.l.	7.6	50
PCB-189	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Σ_{12} DL-PCBs (pg g^{-1})	**337**	**117**	**305**	**490**	**121**	**132**	**724**	**184**	**78**	**86**	**536**	**256**	**448**	**158**	**425**	**95**	**46**	**99**	**3177**	**30**	**53**	**238**	**420**	**265**	**44**	**115**	**6117**	**509**	**2051**
Non-Aroclor																													
PCB-11	**1151**	**416**	**691**	**778**	**542**	**662**	**1126**	**1009**	**262**	**556**	**1117**	**470**	**813**	**691**	**809**	**324**	**<d.l.**	**657**	**289**	**1046**	**520**	**563**	**1079**	**689**	**472**	**458**	**506**	**942**	**616**

<d.l. = Lower than Detection Limit.

[a] Calculated as the sum of PCB-84, PCB-101, and PCB-90.

[b] PCB-118 is both an indicator and a dioxin-like congener.

[c] Calculated as the sum of PCB-138 and PCB-164.

Table 5
Concentrations (in ng g^{-1}) of Polycyclic Aromatic Hydrocarbons (PAHs) as single compounds and total in the studied sites. The high level of Total Organic Carbon and the overall composition of site 28, hampered the reliable analyses of PAHs that were therefore not carried out. Interpretation is fully provided in [1].

PAHs	Site																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30
Acenaphthylene	1.8	0.38	5.7	4.2	0.86	2.6	1.2	1.0	0.49	0.39	56	1.2	3.9	0.72	0.91	0.23	0.18	0.44	0.84	0.012	<d.l.	1.5	1.8	4.9	0.048	<d.l.	0.34	0.90	4.8
Acenaphthene	4.8	2.0	4.2	5.0	1.9	2.4	3.2	2.2	2.2	16	6.5	15	12	2.2	12	5.9	0.82	1.6	0.91	0.72	0.89	<d.l.	<d.l.	2.4	1.3	0.19	2.8	2.2	0.33
Fluorene	33	8.7	22	24	8.6	11	26	13	5.1	8.0	23	11	19	7.1	14	8.1	2.0	8.8	2.4	1.7	7.2	2.8	1.3	12	1.9	<d.l.	2.1	10	23
Phenanthrene	128	50	95	95	78	71	114	76	23	73	94	69	107	25	74	45	14	51	21	21	58	39	26	68	24	11	278	100	116
Anthracene	5.3	0.60	13	11	<d.l.	2.1	<d.l.	1.8	<d.l.	<d.l.	23	1.5	11	1.0	3.7	0.38	0.16	0.41	2.4	0.41	2.4	3.8	2.4	7.5	0.86	<d.l.	1.0	10	7.8
Fluoranthene	83	14	106	133	49	66	38	34	8.4	7.4	606	34	156	13	47	11	2.9	12	20	9.6	27	44	30	23	21	5.4	17	46	22
Pyrene	76	13	71	100	49	47	31	33	8.6	6.8	771	21	194	11	32	7.8	4.7	8.4	16	7.8	23	34	25	18	14	3.5	14	53	24
Benz[*a*]anthracene	40	4.1	76	76	20	41	12	21	2.4	0.19	327	13	167	5.7	16	2.0	0.24	2.7	7.4	2.9	4.4	20	23	1.8	3.1	0.33	5.2	22	4.3
Chrysene	58	6.8	121	91	83	45	21	26	4.4	1.0	408	21	178	9.3	23	3.8	1.0	4.9	13	5.1	9.2	32	32	6.5	6.1	2.3	10	32	15
Benzo [*b*]fluoranthene	47	4.8	84	66	55	33	22	21	2.8	0.37	374	14	154	5.6	16	1.4	0.23	3.0	8.8	2.9	9.0	25	17	4.1	6.6	1.2	6.8	18	7.0
Benzo [k]fluoranthene	20	2.0	38	30	7.2	16	8.2	10	0.80	0.049	173	5.5	70	2.4	6.7	0.42	0.080	1.1	3.2	1.0	2.4	9.6	7.5	0.45	1.4	0.22	2.0	7.9	1.5
Benzo[*a*]pyrene	38	3.6	53	48	7.3	25	15	23	2.2	0.99	281	9.1	197	5.8	11	1.3	0.79	2.8	5.7	2.9	3.4	16	13	1.6	2.1	1.2	3.8	16	3.5
Benzo[ghi]perylene	54	4.4	554	52	22	24	26	33	1.9	0.14	387	10	254	6.4	13	0.89	0.35	2.4	4.9	2.0	3.9	13	9.6	0.69	2.9	0.50	3.8	20	3.9
Indeno [1,2,3-*cd*]pyrene	54	5.4	44	45	25	20	27	30	2.7	0.38	347	8.6	227	6.8	12	1.2	0.84	2.7	4.1	2.0	3.6	11	7.9	0.47	2.4	0.93	3.3	23	5.5
Dibenz [a,h]anthracene	7.4	0.70	15	13	4.1	5.8	3.9	3.3	0.31	0.019	71	2.6	26	0.95	2.8	0.18	0.043	0.47	1.3	0.38	0.78	3.3	2.6	0.31	0.57	0.10	0.79	3.8	1.6
Σ_{15} PAHs	**651**	**121**	**804**	**793**	**410**	**412**	**348**	**329**	**65**	**115**	**3949**	**237**	**1777**	**103**	**284**	**90**	**28**	**103**	**113**	**60**	**154**	**255**	**199**	**152**	**88**	**27**	**100**	**365**	**240**
1% TOC normalized total[a]	80	195	423	317	519	275	77	396	93	52	2821	119	1045	54	430	1139	19	13	49	50	118	159	8	9	31	25	118	281	185

<d.l. = Lower than Detection Limit.
[a] Total PAH concentration normalized for a Total Organic Carbon (TOC) % content of 1 [2].

Table 6
Concentrations (in pg g^{-1}) of PolyBrominated Diphenyls Ethers (PBDEs) as single congeners and total in the studied sites. The high level of Total Organic Carbon and the overall composition of site 28, hampered the reliable analyses of PBDEs that were therefore not carried out. Interpretation is fully provided in [1].

PBDEs	# Br	Site																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	29	30
BDE-17	3	167	67	81	96	68	81	109	97	20	79	121	68	109	<d.l.	64	66	51	70	8.1	9.8	34	23	22	21	19	9.1	10	25	13
BDE-28	3	387	156	211	245	166	199	292	236	51	209	312	163	313	<d.l.	173	157	122	168	36	30	77	67	66	54	56	28	33	67	56
BDE-71	4	33	8.0	12	<d.l.	6.5	10	<d.l.	<d.l.	<d.l.	13	13	6.4	11	<d.l.	<d.l.	<d.l.	16	13	18	17	40	23	25	22	30	16	18	17	9.6
BDE-47	4	22,020	4497	5693	4751	4291	6733	8600	4862	1350	6300	8611	5711	12,131	648	3353	5939	10,392	5082	1057	820	2206	1064	1119	1077	2310	948	1047	1322	1913
BDE-66	4	199	22	27	37	29	32	52	25	6.9	39	76	35	103	5.9	24	38	86	37	8.9	5.9	15	3.5	9.7	6.3	10	1.1	8.1	<d.l.	<d.l.
BDE-100	5	4090	248	316	175	162	459	342	287	<d.l.	375	605	304	1213	<d.l.	267	727	2029	477	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	54	81
BDE-99	5	28,335	1007	1884	968	746	2438	1679	1921	<d.l.	1973	2900	1384	6400	<d.l.	1510	4191	13,297	2747	419	110	482	142	173	120	338	181	122	<d.l.	8.2
BDE-85	5	439	1025	<d.l.	380	<d.l.	42	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	55	<d.l.	<d.l.	<d.l.	207	<d.l.	26	58	27	66	75	324	44	122	80	<d.l.	0.20
BDE-154	6	328	11	21	19	10	19	36	20	<d.l.	13	57	6.6	62	9.0	23	41	136	31	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
BDE-153	6	403	<d.l.	35	28	13	56	52	46	<d.l.	14	16	60	54	64	35	38	116	75	6.5	1.6	19	2.4	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
BDE-138	6	50	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	8.0	9.9	<d.l.	<d.l.	71	7.7	<d.l.	<d.l.	<d.l.	<d.l.
BDE-183	7	190	<d.l.	<d.l.	<d.l.	82	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
BDE-190	7	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
BDE-209	10	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Σ_{14} PBDEs (ng g^{-1})		**57**	**7.0**	**8.3**	**6.7**	**5.6**	**10**	**11**	**7.5**	**1.4**	**9.0**	**13**	**7.7**	**21**	**0.7**	**5.4**	**11**	**27**	**8.7**	**1.6**	**1.1**	**2.9**	**1.4**	**1.5**	**1.7**	**2.8**	**1.3**	**1.3**	**1.5**	**2.1**

<d.l. = Lower than Detection Limit.

Table 7
Concentrations (in pg g^{-1}) of PolyChlorinated Dibenzo-p-Dioxins and Furans (PCDD/Fs) as single congeners and total in the studied sites. Concentrations are expressed also as pg g^{-1} I-TEQ (International Toxic Equivalent). Interpretation is fully provided in [1].

PCDD/Fs	Site				
	1	4	7	11	13
2,3,7,8-TCDD	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
1,2,3,7,8-PeCDD	<d.l.	<d.l.	<d.l.	0.36	<d.l.
1,2,3,4,7,8-HxCDD	<d.l.	<d.l.	0.87	<d.l.	<d.l.
1,2,3,6,7,8-HxCDD	<d.l.	<d.l.	<d.l.	0.82	<d.l.
1,2,3,7,8,9-HxCDD	1.1	1.2	<d.l.	0.16	1.2
1,2,3,4,6,7,8-HpCDD	12	8.8	9.1	7.5	6.4
OCDD	352	302	230	142	170
2,3,7,8-TCDF	0.079	1.2	1.7	3.1	<d.l.
1,2,3,7,8-PeCDF	<d.l.	0.085	0.016	0.68	<d.l.
2,3,4,7,8-PeCDF	0.63	0.080	1.1	0.69	<d.l.
1,2,3,4,7,8-HxCDF	<d.l.	1.6	4.4	<d.l.	<d.l.
1,2,3,6,7,8-HxCDF	0.16	0.63	1.8	1.5	<d.l.
2,3,4,6,7,8-HxCDF	<d.l.	0.38	0.82	0.66	<d.l.
1,2,3,7,8,9-HxCDF	<d.l.	<d.l.	0.81	<d.l.	<d.l.
1,2,3,4,6,7,8-HpCDF	0.80	4.4	3.5	3.9	<d.l.
1,2,3,4,7,8,9-HpCDF	0.23	<d.l.	3.2	1.3	<d.l.
OCDF	<d.l.	0.91	4.0	2.1	<d.l.
Σ_{17} PCDD/Fs	**367**	**321**	**261**	**165**	**178**
I-TEQ[a]	**0.56**	**0.75**	**1.6**	**1.4**	**0.24**

<d.l. = Lower than Detection Limit.
[a] Calculated using the International Toxicity Equivalence Factors (I-TEFs) defined by Van den Berg *et al.* [3].

Table 8
Concentrations (in μg g^{-1}) of OrganoChlorine Pesticides (OCPs) analyzed in the studied sites. Interpretation is fully provided in [1].

OCPs	Site																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
4,4′-DDT	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
4,4′-DDE	<d.l.	4.4	<d.l.	3.1	<d.l.	<d.l.	1.4	<d.l.	<d.l.	<d.l.	3.2	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
4,4′-DDD	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Hexachlorocyclohexane α (α-HCH)	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Hexachlorocyclohexane ß (ß-HCH)	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Hexachlorocyclohexane γ (γ-HCH)	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Heptachlor	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Heptachlor *exo*-epoxide	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Endrin	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Endrin aldehyde	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
α-Endosulfan	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
ß-Endosulfan	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Endosulfan sulfate	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Aldrin	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Dieldrin	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Methoxychlor	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Pretilachlor	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Fenclorim	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Trichlorophenol	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Pentachloronitrobenzene	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.

<d.l. = Lower than Detection Limit.

Table 9
Concentrations (in μg g^{-1}) of Total Petroleum Hydrocarbons (TPHs) as single compounds and total in the studied sites. The high level of Total Organic Carbon and the overall composition of site 28, hampered the reliable analyses of TPHs that were therefore not carried out. Interpretation is fully provided in [1].

TPHs $C_{>12}$	Site										
	19	20	21	22	23	24	25	26	27	29	30
C_{12}	0.25	0.43	0.33	0.24	0.27	0.59	1.2	3.3	1.7	2.1	2.2
C_{13}	0.26	0.34	0.42	2.5	0.29	1.0	1.2	0.99	0.85	0.75	1.6
C_{14}	0.31	0.30	0.50	1.1	0.43	2.0	1.2	0.91	0.60	0.84	1.9
C_{15}	0.47	0.34	0.54	0.89	0.49	2.2	0.91	0.75	0.53	0.72	1.5
C_{16}	0.68	0.54	0.91	1.9	0.77	3.9	1.7	1.2	0.74	0.99	1.7
C_{17}	1.6	0.80	1.4	1.6	1.1	6.1	2.1	1.3	0.95	1.5	2.7
C_{18}	1.4	1.2	1.7	2.1	1.3	4.6	2.6	1.8	1.3	2.2	3.2
C_{19}	0.57	0.95	0.77	0.72	1.0	1.8	1.2	0.88	0.62	1.0	1.8
C_{20}	0.93	0.90	1.0	1.4	0.88	2.3	1.6	1.4	0.82	1.8	1.8
C_{21}	0.37	0.37	0.50	0.39	0.40	1.1	0.97	0.58	0.48	1.1	0.81
C_{22}	0.81	0.85	0.98	1.0	0.85	1.4	1.6	1.3	0.77	1.4	1.2
C_{23}	0.44	0.41	0.82	0.42	0.51	1.2	1.5	0.76	0.73	1.2	0.91
C_{24}	0.83	0.74	1.1	0.78	0.87	1.4	1.7	1.2	0.90	1.3	1.4
C_{25}	0.54	0.55	1.2	0.56	0.66	1.9	1.8	0.93	0.78	1.3	1.0
C_{26}	0.48	0.41	0.90	0.53	0.61	0.71	1.3	1.0	0.73	1.1	0.87
C_{27}	0.67	0.60	1.8	0.87	1.1	0.91	2.6	0.96	0.85	1.2	1.1
C_{28}	0.51	0.40	1.2	0.60	0.64	0.80	1.7	0.96	0.84	1.0	1.0
C_{29}	0.95	0.82	2.9	1.6	2.0	1.1	4.1	1.2	1.1	1.6	1.5
C_{30}	0.53	0.43	1.5	0.76	0.87	0.71	1.9	0.93	0.83	0.98	0.99
C_{31}	1.2	0.81	4.0	2.5	3.2	0.91	4.3	1.2	1.1	1.8	1.5
C_{32}	0.48	0.38	1.2	0.64	0.71	0.47	1.7	0.89	0.80	0.94	0.93
C_{33}	1.3	0.79	3.1	2.0	1.9	6.9	4.2	1.4	1.2	1.7	1.6
C_{34}	0.47	0.46	1.0	0.63	0.49	0.57	1.7	0.84	0.81	1.0	1.1
C_{35}	0.82	0.57	1.5	1.0	0.72	10	2.7	1.2	0.93	1.2	1.3
Σ_{24} TPHs	**17**	**14**	**31**	**27**	**22**	**55**	**47**	**28**	**21**	**31**	**36**

Table 10
Maximum admitted noise levels (dB) during daytime (6 a.m.–9 p.m.) set by Vietnamese environmental regulations. Corresponding standards defined by the Italian laws are presented for comparison. Interpretation is fully provided in [1].

Area	Vietnam[a]	Italy[b]
Residential	70	50
Protected	55	45

[a] National Technical Regulation of Vietnam (*Quy Chuẩn Việt Nam*) QCVN 26:2010.
[b] Decree of the Prime Minister (*Decreto del Presidente del Consiglio dei Ministri*) DPCM 14/11/97.

Table 11
Quality standards (in μg g^{-1}) for metals and pesticides in soils set by Vietnamese environmental regulations. Corresponding standards defined by the Italian laws are presented for comparison. Interpretation is fully provided in [1].

Parameter	Vietnam[a]	Italy[b]
As	12	20
Cd	2	2
Cu	50	120
Pb	70	100
Zn	200	150
Atrazine	0.1	0.01
Benthiocarb	0.1	
Cypermethrin	0.1	
Cartap	0.05	
Dalapon	0.1	
Diazinon	0.05	
Dimethoate	0.05	
Fenobucarb	0.05	
Fenoxaprop-ethyl	0.1	
Fenvalerate	0.05	
Isoprothiolane	0.05	
Metolachlor	0.1	
MPCA[c]	0.1	
Pretilachlor	0.1	
Simazine	0.1	
Trichlorfon	0.05	
2,4-D	0.1	0.01
Aldrin	0.01	0.01
Captan	0.01	
Captafol	0.01	
Chlordimeform	0.01	
Chlordane	0.01	0.01
DDT	0.01	0.01
Dieldrin	0.01	0.01
Endosulfan	0.01	
Endrin	0.01	0.01
Heptachlor	0.01	
Hexachlorobenzene	0.01	0.05
Isobenzen	0.01	
Isodrin	0.01	
Lindane	0.01	0.01
Methamidophos	0.01	
Monocrotophos	0.01	
Methyl Parathion	0.01	
Na-pentachlorophenate-monohydrate	0.01	
Parathion Ethyl	0.01	
Pentachlorophenol	0.01	0.01
Phosphamidon	0.01	
Polychlorocamphene	0.01	

[a] National Technical Regulations of Vietnam (*Quy Chuẩn Việt Nam*) QCVNs 03:2008 and 15:2008.
[b] Column A, Table 1, Annex 5, Title V, Legislative Decree (*Decreto Legislativo*) D.Lgs. 152/2006.
[c] 2-Methyl-4-chlorophenoxyacetic acid.

Table 12
Quality standards (in μg m^{-3}) for inorganic and organic compounds in the atmosphere as hourly average (if not differently expressed) set by Vietnamese environmental regulations. Corresponding standards defined by the Italian laws are presented for comparison. Interpretation is fully provided in [1].

Parameter	Vietnam[a]	Italy[b]
As	0.03	0.006[j]
AsH_3	0.3	
HCl	60[f]	
HNO_3	400	
H_2SO_4	300	
Silica dust	150	
SO_2	125[f]	125[f]
CO	5000[f]	10.000[f]
NO_x	100[f]	200
O_3	80[f]	120[f]
TSP[c]	200[f]	
PM 10[d]	150[f]	50[f]
Chrysotile[e]	1[g]	100.000[k]
Cd	0.4	0.005[j]
Cl_2	100	
Cr^{6+}	0.007	
HF	20	
HCN	10	
Mn/MnO_2	10	
Ni	1[f]	0.02[j]
Hg	0.3[f]	
Pb	1.5[f]	0.5[h]
Acrolein	50	
Acrylonitrile	45[f]	
Aniline	50	
Acrylic acid	54[h]	
Benzene	22	5[h]
Benizidine	n.d.[i]	
Chloroform	16[f]	
Hydrocarbons	5000	
Formaldehyde	20	
Naphthalene	120[f]	0.001[l]
Phenols	10	
Tetrachloroethylene	100[f]	
Vinyl chloride	26[f]	7770[m]

[a] National Technical Regulations of Vietnam (*Quy Chuẩn Việt Nam*) QCVNs 05:2009 and 06:2009.
[b] Legislative Decrees D.Lgs. 66/2000, 257/2006 and 155/2010.
[c] Total Suspended Particles.
[d] Particulate Matter.
[e] Expressed in fiber m^{-3}.
[f] Daily average.
[g] Absolute value.
[h] Annual average.
[i] Not Detectable.
[j] Target annual average measured in PM 10.
[k] Limit for exposed workers, as Asbestos.
[l] Target annual average of Benzo[*a*]pyrene measured in PM 10.
[m] Limit for exposed workers.

Table 13
Emission limits in air (in mg Nm^{-3}) for dust, inorganic and organic compounds set by Vietnamese environmental regulations. Corresponding limits defined by the Italian laws are presented for comparison. Interpretation is fully provided in [1].

Parameter	Vietnam[a]	Italy[b]
Dust	200	50
Silica dust	50	5[e]
NH_4^+	50	250
Sb	10	5
As	10	1
Cd	5	0.1
Pb	5	5
CO	1000	350[f]
Cl^-	10	5
Cu	10	5
Zn	30	
HCl	50	30
HF	20	5
H_2S	7.5	5
SO_2	500	500
NO_2	850	500
NO_2[c]	1000	500
H_2SO_4	50	
HNO_3	500	
1,1,2,2-Tetrabromoethane	14	
Acetaldehyde	270	20
Acrolein	2.5	
Amyl acetate	525	300
Aniline	19	20
Benzidine	n.d.[d]	1
Benzene	5	5
Benzyl chloride	5	20
1,3-Butadiene	2200	5
n-Butyl acetate	950	300
Butylamine	15	20
Cresols	22	20
Chlorobenzene	350	150
Chloroform	240	20
2-Chloro-1,3-butadiene	90	150
Trichloro-nitromethane	0.7	5
Cyclohexane	1300	600
Cyclohexanol	410	
Cyclohexanone	400	150
Cyclohexene	1350	600
Diethylamine	75	20
Dibromodifluoromethane	860	600[g]
o-Dichlorobenzene	300	150
1,1-Dichloroethane	400	150
1,2-Dichloroethylene	790	20
1,4-Dioxane	360	5
Dimethylaniline	25	20[h]
2-Chloroethyl ether	90	20
Dimethylformamide	60	150
Dimethyl sulfate	0.5	1
Dimethylhydrazine	1	5
Dinitrobenzene	1	5
Ethyl acetate	1400	600
Ethylamine	45	20
Ethylbenzene	870	150
Bromoethane	890	5[i]

(*continued on next page*)

Table 13 (*continued*)

Parameter	Vietnam[a]	Italy[b]
Ethylenediamine	30	20[j]
1,2-Dibromoethane	190	5
Ethyl acrylate	100	5
2-Chloroethanol	16	
Ethylene oxide	20	5
Diethyl ether	1200	600
Chloroethane	2600	150[k]
Tetraethyl orthosilicate	850	
Ethanolamine	45	20
Furfural	20	20
Formaldehyde	20	20
Furfuryl alcohol	120	
Trichlorofluoromethane	5600	600
n-Heptane	2000	600
n-Hexane	450	150
Isopropylamine	12	20
n-Butanol	360	150
Methyl mercaptan	15	5[l]
Methyl acetate	610	300
Methyl acrylate	35	5
Methanol	260	150
Methylacetylene	1650	600
Methyl bromide	80	20
Methylcyclohexane	2000	600
Methylcyclohexanol	470	
Methylcyclohexanone	460	150
Methyl chloride	210	20
Methylene chloride	1750	20
Methyl Chloroform	2700	150
n-Methylaniline	9	20
Methanolamine	31	
Naphthalene	150	150
Nitrobenzene	5	5[m]
Nitroethane	310	20
Nitroglycerin	5	5
Nitromethane	250	20
2-Nitropropane	1800	5
Nitrotoluene	30	20
2-Pentanone	700	150[n]
Phenol	19	20
Phenylhydrazine	22	5[o]
n-Propanol	980	300
n-Propyl acetate	840	300
1,2-Dichloropropane	350	150
Propylene oxide	240	5[p]
Pyridine	30	20
Pyrene	15	0.1[q]
p-Benzoquinone	0.4	
Styrene	100	150
Tetrahydrofuran	590	150
1,1,2,2-Tetrachloroethane	35	20
Tetrachloroethylene	670	20
Tetrachloromethane	65	20[r]
Tetranitromethane	8	20
Toluene	750	300
o-Toluidine	22	20[s]
Toluene 2,4-diisocyanate	0.7	5
Triethylamine	100	20
1,1,2-Trichloroethane	1080	600[t]

Table 13 (*continued*)

Parameter	Vietnam[a]	Italy[b]
Trichloroethylene	110	20
Xylene	870	300
Xylidine	50	20[h]
Vinyl chloride	20	5
Vinyltoluene	480	150

[a] National Technical Regulations of Vietnam (*Quy Chuẩn Việt Nam*) QCVNs 19:2009 and 20:2009.
[b] Legislative Decree (*Decreto Legislativo*) D.Lgs. 152/2006.
[c] From chemical plants.
[d] Not Detectable.
[e] Expressed as SiO_2.
[f] For combustion plants with nominal installed thermal power between 1.5 and 3 MW.
[g] Expressed as 1,2-Dibromo-1,1-difluoroethane.
[h] Expressed as Methylaniline.
[i] Expressed as 1,2-Dibromoethane.
[j] Expressed as Ethylamine.
[k] Expressed as Dichloroethane.
[l] Expressed as Ethyl mercaptan.
[m] Expressed as Dinitrobenzene.
[n] Expressed as Dipropyl ketone.
[o] Expressed as Hydrazine.
[p] Expressed as Ethylene oxide.
[q] Expressed as Benzo[*a*]pyrene.
[r] Expressed as Tetrachloroethane.
[s] Expressed as *m*, *p*-Toluidine.
[t] Expressed as Trichloromethane.

Table 14
Quality standards in drinking and groundwaters set by Vietnamese environmental regulations. Corresponding standards defined by the Italian laws are presented for comparison. Interpretation is fully provided in [1].

Parameter	Unit	Drinking waters		Groundwaters	
		Vietnam[a]	Italy	Vietnam[b]	Italy[n]
Color	TCU[f]	15	Acceptable[j]		
Odor and taste		None	Acceptable[j]		
Turbidity	NTU[g]	2	1[j]		
pH		6.5–8.5	6.5–8.5[k]	5.5–8.5	
Hardness	mg L^{-1}	300	100–500[j]	500	
Total suspended solids	mg L^{-1}	1000	25[k]	1500	
Al	mg L^{-1}	0.2	0.2[j]		0.2
NH_4^+	mg L^{-1}	3	0.5[j]	0.1	
Sb	mg L^{-1}	0.005	0.005[j]		0.005
As	mg L^{-1}	0.01	0.01[j]	0.05	0.01
Ba	mg L^{-1}	0.7	0.1[k]		
B	mg L^{-1}	0.3	1[j]		1
Cd	mg L^{-1}	0.003	0.001[k]	0.005	0.005
Cl^-	mg L^{-1}	250–300	200[k]	250	
Cr^{3+}	mg L^{-1}	0.05[i]	0.05[i,j]		
Cr^{6+}	mg L^{-1}			0.05	0.005
Cu	mg L^{-1}	1	0.02[k]	1	1
CN^-	mg L^{-1}	0.07	0.05[j]	0.01	0.05
F^-	mg L^{-1}	1.5	0.7–1[j]	1	1.5
H_2S	mg L^{-1}	0.05			
Fe	mg L^{-1}	0.3	0.1[k]	5	0.2
Pb	mg L^{-1}	0.01	0.01[j]	0.01	0.01
Mn	mg L^{-1}	0.3	0.05[j]	0.5	0.05
Hg	mg L^{-1}	0.001	0.0005[k]	0.001	0.001
Mo	mg L^{-1}	0.07			
Ni	mg L^{-1}	0.02	0.02[j]		0.02

(*continued on next page*)

Table 14 (*continued*)

Parameter	Unit	Drinking waters		Groundwaters	
		Vietnam[a]	Italy	Vietnam[b]	Italy[n]
NO_2^-	mg L^{-1}	3	0.5[j]	1	0.5
NO_3^-	mg L^{-1}	50	25[k]	15	
Se	mg L^{-1}	0.01	0.01[j]	0.01	0.01
Na	mg L^{-1}	200	200[j]		
SO_4^{2-}	mg L^{-1}	250	150[k]	400	250
Zn	mg L^{-1}	3	0.5[k]	3	3
MnO_4^-	mg L^{-1}	2			
COD[c]	mg L^{-1}			4	
Carbon tetrachloride	μg L^{-1}	2			
Dichloromethane	μg L^{-1}	20			
1,2-Dichloroethane	μg L^{-1}	30	3[j]		3
1,1,1-Trichloroethane	μg L^{-1}	2000			0.2
Vinyl chloride	μg L^{-1}	5	0.5[j]		0.5
1,2-Dichloroethene	μg L^{-1}	50			60
Trichloroethylene	μg L^{-1}	70	10[j,l]		1.5
Tetrachloroethylene	μg L^{-1}	40			1.1
Phenols	mg L^{-1}	0.001		0.001	
Benzene	μg L^{-1}	10	1		1
Toluene	μg L^{-1}	700			15
Xylenes	μg L^{-1}	500			10
Ethylbenzene	μg L^{-1}	300			50
Styrene	μg L^{-1}	20			25
Benzo[*a*]pyrene	μg L^{-1}	0.7	0.01[j]		0.01
Monochlorobenzene	μg L^{-1}	300			40
1,2-Dichlorobenzene	μg L^{-1}	1000			270
1,4-Dichlorobenzene	μg L^{-1}	300			0.5
Trichlorobenzene	μg L^{-1}	20			190
Bis(2-ethylhexyl)adipate	μg L^{-1}	80			
Bis(2-ethylhexyl)phthalate	μg L^{-1}	8			
Acrylamide	μg L^{-1}	0.5	0.1[j]		0.1
Epichlorohydrin	μg L^{-1}	0.4			
Hexachlorobutadiene	μg L^{-1}	0.6			0.15
Aldrin + Dieldrin	μg L^{-1}	0.03	0.06[j]		0.06
Heptachlor + H. epoxide	μg L^{-1}	0.03	0.06[j]		
Alachlor	μg L^{-1}	20	0.1[j]		0.1
Aldicarb	μg L^{-1}	10	0.1[j]		
Atrazine	μg L^{-1}	2	0.1[j]		0.3
Bentazon	μg L^{-1}	30	0.1[j]		
Carbofuran	μg L^{-1}	5	0.1[j]		
Chlordane	μg L^{-1}	0.2	0.1[j]		0.1
Chlortoluron	μg L^{-1}	30	0.1[j]		
DDT	μg L^{-1}	2	0.1[j]		0.1
1,2-Dibromo-3- chloropropane	μg L^{-1}	1	0.1[j]		
2,4-Dichlorophenoxyacetic acid	μg L^{-1}	30	0.1[j]		
1,2-Dichloropropane	μg L^{-1}	20	0.1[j]		
1,3-Dichloropropene	μg L^{-1}	20	0.1[j]		
Hexachlorobenzene	μg L^{-1}	1	0.1[j]		0.01
Isoproturon	μg L^{-1}	9	0.1[j]		
Lindane	μg L^{-1}	2	0.1[j]		0.1
MCPA[d]	μg L^{-1}	2	0.1[j]		
Methoxychlor	μg L^{-1}	20	0.1[j]		
Metolachlor	μg L^{-1}	10	0.1[j]		
Molinate	μg L^{-1}	6	0.1[j]		
Pendimetalin	μg L^{-1}	20	0.1[j]		
Pentachlorophenol	μg L^{-1}	9	0.1[j]		
Permethrin	μg L^{-1}	20	0.1[j]		
Propanil	μg L^{-1}	20	0.1[j]		
Simazine	μg L^{-1}	20	0.1[j]		
Trifluralin	μg L^{-1}	20	0.1[j]		
2,4-DB[e]	μg L^{-1}	90	0.1[j]		

Table 14 (*continued*)

Parameter	Unit	Drinking waters		Groundwaters	
		Vietnam[a]	Italy	Vietnam[b]	Italy[n]
Dichlorprop	μg L^{-1}	100	0.1[j]		
Fenoprop	μg L^{-1}	9	0.1[j]		
Mecoprop	μg L^{-1}	10	0.1[j]		
2,4,5-Trichlorophenoxyacetic acid	μg L^{-1}	9	0.1[j]		
Monochloramine	μg L^{-1}	3			
Chlorine residues	mg L^{-1}	0.3–0.5			
Bromate	μg L^{-1}	25	10[j]		
Chlorite	μg L^{-1}	200	200[j]		
2,4,6-Trichlorophenol	μg L^{-1}	200			
Formaldehyde	μg L^{-1}	900			
Bromoform	μg L^{-1}	100			
Dibromochloromethane	μg L^{-1}	100	100[j,m]		0.13
Bromodichloromethane	μg L^{-1}	60			0.17
Chloroform	μg L^{-1}	200			
Dichloroacetic acid	μg L^{-1}	50			
Trichloroacetic acid	μg L^{-1}	100			
Trichloroacetaldehyde	μg L^{-1}	10			
Dichloroacetonitrile	μg L^{-1}	90			
Dibromoacetonitrile	μg L^{-1}	100			
Trichloroacetonitrile	μg L^{-1}	1			
Total α emission	Bq L^{-1}	0.11		0.1	
Total β emission	Bq L^{-1}	1.11		1	
Escherichia Coli	MPN[h] 100 mL^{-1}	0	0[j]	0	
Coliforms	MPN[h] 100 mL^{-1}	0	0[j]	3	

[a] National Technical Regulation of Vietnam (*Quy Chuẩn Việt Nam*) QCVNs 01:2009.
[b] National Technical Regulation of Vietnam (*Quy Chuẩn Việt Nam*) QCVNs 09:2008.
[c] Chemical Oxygen Demand.
[d] 2-Methyl-4-chlorophenoxyacetic acid.
[e] 4-(2,4-Dichlorophenoxy)butyric acid.
[f] True Color Unit.
[g] Nephelometric Turbidity Unit.
[h] Most Probable Number.
[i] Expressed as total Cr.
[j] Annex 1, Legislative Decree (*Decreto Legislativo*) D.Lgs. 31/2001.
[k] Guide or imperative level in column A1, Table 1/A, Annex 2, Title III, Legislative Decree (*Decreto Legislativo*) D.Lgs. 152/2006.
[l] Expressed as sum of both compounds.
[m] Expressed as sum of the three compounds.
[n] Table 2, Annex 5, Title V, Legislative Decree (*Decreto Legislativo*) D.Lgs. 152/2006.

Table 15
Quality standards in sediments set by Vietnamese environmental regulations. Corresponding standards defined by the Italian laws are presented for comparison. Interpretation is fully provided in [1].

Parameter	Unit (on dry weight)	Vietnam[a]		Italy[b]
		Freshwater	Saline and brackish water	
As	μg g^{-1}	14	41.6	20
Cd	μg g^{-1}	3.5	4.2	2
Pb	μg g^{-1}	91.3	112	100
Zn	μg g^{-1}	315	271	150
Hg	μg g^{-1}	0.5	0.7	1
Cr	μg g^{-1}	90	160	150
Cu	μg g^{-1}	197	108	120
Total Hydrocarbons	μg g^{-1}	100	100	60
Chlordane	ng g^{-1}	8.9	4.8	10
DDD	ng g^{-1}	8.5	7.8	10[c]
DDE	ng g^{-1}	6.8	374	
DDT	ng g^{-1}	4.8	4.8	
Dieldrin	ng g^{-1}	6.7	4.3	10
Endrin	ng g^{-1}	62.4	62.4	10

(*continued on next page*)

Table 15 (*continued*)

Parameter	Unit (on dry weight)	Vietnam[a]		Italy[b]
		Freshwater	Saline and brackish water	
Heptachlor epoxide	ng g^{-1}	2.7	2.7	
Lindane	ng g^{-1}	1.4	1.0	10
Sum of PCBs	ng g^{-1}	277	189	60
PCDD/Fs	pg g^{-1}[d]	21.5	21.5	10
Acenaphthene	ng g^{-1}	88.9	88.9	10,000[e]
Acenaphthylene	ng g^{-1}	128	128	
Anthracene	ng g^{-1}	245	245	
Benzo[*a*]anthracene	ng g^{-1}	385	693	500
Benzo[*a*]pyrene	ng g^{-1}	782	763	100
Chrysene	ng g^{-1}	862	846	5000
Dibenzo[a,h]anthracene	ng g^{-1}	135	135	100
Fluroanthene	ng g^{-1}	2355	1494	
Fluorene	ng g^{-1}	144	144	
2-Methylnaphthalene	ng g^{-1}	201	201	
Naphthalene	ng g^{-1}	391	391	
Phenanthrene	ng g^{-1}	515	544	
Pyrene	ng g^{-1}	875	1398	5000

[a] National Technical Regulation of Vietnam (*Quy Chuẩn Việt Nam*) QCVN 43:2012.
[b] Column A, Table 1, Annex 5, Title V, Legislative Decree (*Decreto Legislativo*) D.Lgs. 152/2006.
[c] As sum of DDD, DDT, and DDE.
[d] As TEQs [3].
[e] As sum of Benzo[*a*]anthracene, Benzo[*a*]pyrene, Benzo[*b*]fluoranthene, Benzo[k]fluoranthene, Benzo[g,h,i]perylene, Chrysene, Dibenzo[a,e]pyrene, Dibenzo[a,l]pyrene, Dibenzo[a,i]pyrene, Dibenzo[a,h]pyrene, Dibenzo[a,h]anthracene, Indenopyrenea and Pyrene.

Quality standards and emission limits set by Vietnamese regulations have been compared with Italian ones (updated to October 2012; Tables 10–15). This choice was motivated by the fact that Italy has a longer history of industrial and economic development than Vietnam and has already faced environmental and health risks that Vietnam is presently requested to manage.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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