

CRITERIA

Cr(VI) Impacted water bodies in the Mediterranean: Transposing management options for Efficient water Resources use through an Interdisciplinary Approach

Mid-term Report

UNIROMA1

Part 2: Report on industrial water consumption in Italy and selected regions

Although Italy is a country that have limited raw material resources and energy sources, the industrial growth is widespread and consistent throughout the national territory in different industrial sectors. The industrial sectors covers 31% of the GDP and employees 33% of the workers.

Most of the industrial activities requires water during process and production. In Italy, the water consumption by industry is equal to 5.5 Bm³/y, as reported in detail in Table 1.

Companies having more than 5+ employees accounts for 99.8% of the total industrial water consumption. For this reason, the analysis of the industrial situation in Italy is restricted to those industrial companies classified as medium or big.

It is very difficult to estimate the water consumption of a sector compared to other ones. Indeed, it depends on the variety of plant capacities and processes used, as well of the possibility to recycle water back to the process.

A criterion to evaluate the environmental impact of the water consumption by comparing the different industrial sectors is the Water Use Intensity indicator (WUI), that is the ratio between the volume of consumed water to generate a unity of the production value. The relevant data is reported in the last column of Table 1.

The water consumption is very different concerning the regions in Italy, where most of the industrial activities are concentrated in the northern part of the country. In Table 2, the different industrial activities are report by regions.

From the data in Table 1 and 2, it is possible to notice that the industry distribution and the relevant water consumption in the different sectors did not correspond. Indeed, it appear that in particular the CH and PC industry is concentrated in big, few sites, accounting one fourth of the total water requirements of the industry. On contrary, ME, MA and FO industries appears to be a majority of medium size companies, representing the 59.6%, but requiring only 21.7% of water.

Table 1: Average water consumption by identified industrial activity

Industrial activity	ID	Water consumption [Mm³/y]	Water consumption [%]	WUI [L water/€]
Chemicals	CH	680.8	12.56%	18
Petrochemical (incl. plastics)	PC	645.4	11.90%	19
Metallurgic	ME	552.1	10.18%	10
Machinery	MA	424.7	7.83%	3
Non-ferrous minerals	NM	419.0	7.73%	18
Paper	PA	354.6	6.54%	18
Textile	TE	348.5	6.43%	24
Food	FO	333.0	6.14%	4
Cement and Ceramics	CC	294.0	5.42%	10
Automotive	AU	285.6	5.27%	9
Mineral extraction	MX	260.7	4.81%	75
Electronics and optics	EO	260.2	4.80%	5
Clothing	CL	147.5	2.72%	6
Wood	WO	120.2	2.22%	12
Furniture	FU	116.1	2.14%	6
Beverages	BE	92.5	1.71%	6
Tannery	TA	43.8	0.81%	3
Pharmaceutical	PH	40.2	0.74%	4
Other	OT	2.5	0.05%	19
TOTAL		5421.4	100.0%	-

Table 2: Industrial water consumption by region and macro sectors

Region	Area	Number of industries	CH	PC	ME	MA	NM	PA	TE	FO	OT	AU	MX	EO	CL	WO	FU	BE	TA	PH
Valle d'Aosta	North	233	0.0	0.0	15.9	12.4	0.4	0.0	1.7	36.9	5.2	0.0	3.9	3.4	0.0	18.0	0.0	2.1	0.0	0.0
Piemonte		13960	2.5	0.1	30.3	17.5	0.4	2.0	7.4	14.3	3.0	3.9	1.3	6.2	0.4	6.0	1.1	0.7	2.6	0.2
Lombardia		42825	4.0	0.0	31.0	15.4	0.6	2.6	7.7	9.1	2.3	1.8	0.9	8.3	1.6	5.4	2.7	0.2	5.6	0.7
Trentino – Alto Adige		3005	1.4	0.0	17.7	11.8	0.1	1.6	2.2	20.5	4.7	0.7	5.3	4.2	0.3	24.6	2.3	1.4	1.0	0.2
Veneto		23987	2.2	0.0	23.4	15.4	0.3	2.2	3.8	10.1	3.9	1.8	0.7	7.0	3.0	7.8	5.4	0.6	12.3	0.1
Friuli Venezia Giulia		4195	1.7	0.0	25.3	16.5	0.3	1.5	1.6	13.6	3.4	2.2	1.0	5.6	0.3	11.3	13.4	0.7	1.2	0.2
Emilia Romagna		19055	2.7	0.0	26.4	18.2	0.3	1.9	3.2	17.5	3.5	2.4	0.6	7.0	2.1	4.4	2.0	0.4	7.2	0.2
Liguria		3160	3.4	0.0	18.5	20.0	0.3	1.0	0.9	35.3	3.3	3.9	1.5	6.3	0.1	3.2	0.6	0.2	0.9	0.6
Toscana	Center	17326	1.8	0.0	11.9	8.4	0.2	3.1	13.3	11.5	3.3	2.2	1.8	3.6	4.7	5.1	2.8	0.3	25.7	0.2
Umbria		3137	1.7	0.0	19.5	13.0	0.3	2.9	6.0	18.7	5.6	1.8	1.7	3.9	3.6	6.8	2.4	0.7	11.0	0.1
Marche		8983	1.3	0.0	17.1	8.3	0.2	2.3	2.4	11.7	2.2	1.7	0.6	5.5	13.2	6.2	6.0	0.2	21.0	0.1
Lazio		6876	3.1	0.1	17.2	18.1	0.3	2.1	1.5	25.5	6.0	2.5	3.5	6.2	0.2	6.4	1.8	0.5	3.6	1.5
Abruzzo	South	3583	2.2	0.1	17.7	14.3	0.5	2.5	5.0	21.1	4.7	2.7	1.8	3.4	1.3	6.0	2.3	1.0	13.3	0.2
Molise		564	1.4	0.0	13.3	12.6	1.1	2.1	2.1	35.8	6.0	2.0	2.7	3.7	0.2	7.1	1.4	0.5	7.6	0.4
Campania		8746	2.2	0.0	16.1	13.7	0.4	2.7	2.6	25.0	4.2	2.8	1.1	3.5	3.8	4.4	1.0	0.4	15.7	0.4
Puglia		7589	1.4	0.0	12.6	13.6	0.1	1.8	3.6	28.6	5.3	1.6	3.3	2.1	3.4	5.0	3.1	1.0	13.2	0.1
Basilicata		849	0,7	0,0	17,0	14,6	0,5	0,7	2,4	31,6	6,8	2,5	4,7	2,7	0,2	5,7	6,2	1,1	2,2	0,5
Calabria		1840	2.2	0.0	13.6	14.1	0.2	0.9	2.2	37.7	9.5	0.7	2.6	2.2	0.3	9.0	1.7	0.8	2.3	0.0
Sardegna	Island	2282	1.9	0.0	11.7	12.9	0.3	1.1	1.5	40.0	7.4	1.1	6.7	1.4	0.1	11.9	0.2	1.3	0.6	0.0
Sicilia	Island	5283	2.4	0.0	13.8	16.9	0.3	1.6	0.9	35.0	8.7	2.5	3.8	1.9	0.3	6.4	1.4	1.7	1.9	0.3
ITALY		177478	2.0	0.0	18.5	14.4	0.4	1.8	3.6	24.0	5.0	2.0	2.5	4.4	2.0	8.0	2.9	0.8	7.4	0.3

The CRITERIA project focuses on the industrial site nearby the Pollino national park, which is a delimited area within the Basilicata region. The relevant districts are reported in Table 3.

Table 3: Districts of the Pollino area

District	ID	Region	Total population	Area [km ²]
CASTELLUCCIO INFERIORE	CI	Basilicata	2028	28.96
CASTELLUCCIO SUPERIORE	CS	Basilicata	809	32.98
EPISCOPIA	EP	Basilicata	1402	28.64
FRANCAVILLA IN SINNI	FS	Basilicata	4176	46.82
LATRONICO	LA	Basilicata	4467	76.66
SAN SEVERINO LUCANO	SS	Basilicata	1520	61.16
VIGGIANELLO	VI	Basilicata	3124	120.84
TOTALE		-	17526	396.06

The industry in the Pollino area appears to be low density, as reported in Table 4. By the data in Table 1, it is possible to estimate the industrial water consumption of the Pollino area as follows:

in a first step, from Table 1, the average water consumption of the sector for each industrial site is calculated; then, this value is multiplied by the industrial sites that are in the Pollino area (Table 4). The calculations and the relevant results are added in the last rows of Table 4.

The industrial water requirements of the Pollino area appears to be specific to the local conditions and the activities, differing from those in average of the country and the region.

A total of 3500 km³/y of industrial water was estimated to be required in the area for the industrial activities, that is equal to 6.36‰ of the national industrial water consumption used by 6.87‰ of the national industrial companies.

Most of the water is used by PC, ME and MX. The latter one is characterized by far having the worst WUI, therefore the industrial water use in the Pollino area is not well valorised. On the other hand, Basilicata region is the only one in south Italy not suffering limits of available water: the theoretical basin capacity for water is equal to 745 m³/y, and the region has the possibility to cover its needs and to provide water to nearby regions, such as Puglia and Molise.

By adopting a deeper analysis procedure, in the Pollino area following relevant industries (5+ employees; give their balance sheet public in year 2016) were identified and hereafter reported in unlabelled tables.

From the balance sheet, the value of the production was known, and applying the relevant WUI value of the sector, an estimation of the water consumption was calculated. Although the approach evaluates average values for the sector, the procedure will give rise to some error. On the other side, the precise technologies in use of every company are not known, and thus a precise evaluation of the water consumption was not possible. There should be some margin that particular technologies in use to some companies may compensate higher water consumption by others using traditional or conventional ones.

It was estimated that the margin of error by adopting this procedure has to be considered within \pm 20%.

Table 4: Industry in the Pollino area and estimated water consumption

Sector	Number of industries in the Pollino area by districts							TOTAL	% POLLINO AREA	% BASILICATA REGION	Estimated water consumption		
	CI	CS	EP	FS	LA	SS	VI				TOTAL [km ³ /y]	% POLLINO AREA	% ITALY
CH	0	0	0	0	0	0	0	0	0.0%	0.7%	0.0	0.0%	12.56%
PC	0	0	0	1	0	0	0	1	0.8%	0.0%	537.8	15.3%	11.90%
ME	9	3	1	11	13	0	3	40	32.8%	17.0%	672.6	19.2%	10.18%
MA	0	0	0	3	1	0	1	5	4.1%	14.6%	83.1	2.4%	7.83%
NM	0	0	0	0	0	0	0	0	0.0%	0.5%	0.0	0.0%	7.73%
PA	0	0	0	0	0	0	0	0	0.0%	0.7%	0.0	0.0%	6.54%
TE	2	0	0	0	1	0	1	4	3.3%	2.4%	218.2	6.2%	6.43%
FO	4	1	4	5	8	3	1	26	21.3%	31.6%	203.3	5.8%	6.14%
OT	0	0	0	0	0	0	0	0	0.0%	6.8%	0.0	0.0%	5.42%
AU	0	0	0	0	0	0	0	0	0.0%	2.5%	0.0	0.0%	5.27%
MX	3	1	0	6	5	0	0	15	12.3%	4.7%	881.3	25.1%	4.81%
EO	0	0	1	0	0	0	0	1	0.8%	2.7%	33.3	1.0%	4.80%
CL	0	0	1	1	3	0	0	5	4.1%	0.2%	207.8	5.9%	2.72%
WO	1	1	1	7	2	3	1	16	13.1%	5.7%	135.5	3.9%	2.22%
FU	0	0	0	1	0	0	1	2	1.6%	6.2%	45.1	1.3%	2.14%
BE	0	0	0	2	0	1	1	4	3.3%	1.1%	260.6	7.4%	1.71%
TA	0	0	0	0	0	0	0	0	0.0%	2.2%	0.0	0.0%	0.81%
PH	0	0	3	0	0	0	0	3	2.5%	0.5%	226.5	6.5%	0.74%
TOTAL								122	100.0%	100.0%	3505.1	100.0%	100.0%

Petrolchemical (incl. plastics) – PC

- Total companies in the Pollino area: 1
- Total identified companies: none
- WUI: 18 L water / € production
- Cr pollution in wastewaters: neglectable

Due to the lack of data and small number of companies, this sector was neglected.

Metallurgic – ME

- Total companies in the Pollino area: 40
- Total identified companies: none
- WUI: 10 L water / € production
- Cr pollution in wastewaters: NOT neglectable, avg. 0.4 mg Cr / L WW, 0.4 m³ WW / t steel.

Due to the lack of data, but in presence of a relevant number of small enterprises, mean values were estimated by national / other regional data. Since these companies are small, most probably they are specialized in metal (steel/aluminium) casting.

In order to cast 1t of steel, 25 m³ of water are required. Since these are small enterprises, their capacity was evaluated to be approx. 1000t steel per year, and, consequently, the water consumption was estimated to be 25 km³ per year. Concerning Cr pollution, each company give rise to 400 m³ WW containing 160 g Cr per year.

Machinery – MA

- Total companies in the Pollino area: 5
- Total identified companies: 3 (60%)
- WUI: 3 L water / € production
- Cr pollution in wastewaters: neglectable

Company name	FALABELLA EGIDIO & C. - S.R.L.	EDILMACCHINE VECCHIONE S.R.L.	COSAPPO S.R.L.
Address	LOCALITA' S. ANTONIO - ZONA P.I.P. 1	PIAZZA UMBERTO I 20	CONTRADA TORRE 23
Industrial sector	MA	MA	MA
District	LATRONICO - PZ	LATRONICO - PZ	LATRONICO - PZ
Employed	19	12	11
Share capital [€]	90000	160000	78000
Declared value of the production [€/y]	1619585	1580638	392171
Declared revenue [€/y]	1513640	1512450	380621
Main product	Industrial machinery	Industrial machinery	Industrial machinery
Estimated water consumption [m³/y]	4859	4742	1177
Estimated total water consumption of identified companies of the sector [m³/y]			10777

Textile – TE

- Total companies in the Pollino area: 4
- Total identified companies: 2 (50%)
- WUI: 24 L water / € production
- Cr pollution in wastewaters: NOT neglectable, avg. 600 mg/L WW, 90% WW / water.

Company name	CALVO MARIA S.R.L.	M.M.R. CONFEZIONI - SOCIETA' COOPERATIVA
Address	LOCALITA' LE ISCHIE ZONA P.I.P. LOTTO B9	CONTRADA PIETRASASSO - ZONA 3
Industrial sector	TE	TE
District	FRANCAVILLA IN SINNI - PZ	CASTELLUCCIO INFERIORE - PZ
Employed	16	6
Share capital [€]	58800	N/A
Declared value of the production [€/y]	479359	6776
Declared revenue [€/y]	306946	0
Main product	Textiles	Textiles
Estimated water consumption [m³/y]	11505	163
Estimated total water consumption of identified companies of the sector [m³/y]		11667

Food – FO

- Total companies in the Pollino area: 26
- Total identified companies: 5 (19%)
- WUI: 4 L water / € production
- Cr pollution in wastewaters: neglectable

Company name	PASTA PASTA - SRL	LONGO S.R.L.	ASID S.R.L.	IL FRANTOIO DELLA CERTOSA-SRL	SOCIETA' COOPERATIVA LA GINESTRA RL
Address	ZONA P.I.P. SNC	VIA PALMIRO TOGLIATTI 11	CONTRADA PIETRASASSO SNC	CONTRADA PASSEGGERI 25	CONTRADA PEZZO LA CORTE 20
Industrial sector	FO	FO	FO	FO	FO
District	EPISCOPIA - PZ	LATRONICO - PZ	CASTELLUCCIO INFERIORE - PZ	FRANCAVILLA IN SINNI - PZ	VIGGIANELLO - PZ
Employed	11	10	9	7	6
Share capital [€]	10200	10500	119000	10500	N/A
Declared value of the production [€/y]	283031	251990	171813	17527	3331
Declared revenue [€/y]	275057	251975	108293	17527	28531
Main product	Pasta	Baked goods	Meat	Olive oil	Meat
Estimated water consumption [m³/y]	1132	1008	687	70	13
Estimated total water consumption of identified companies of the sector [m³/y]					2911

Mineral extraction – MX

- Total companies in the Pollino area: 15
- Total identified companies: 1 (7%)
- WUI: 75 L water / € production
- Cr pollution in wastewaters: neglectable

Company name	VIGGIANELLO FONTI DEL POLLINO S.P.A.
Address	LOCALITA' FIUMARA S.P. 4 S/N
Industrial sector	MX
District	VIGGIANELLO - PZ
Employed	18
Share capital [€]	3000000
Declared value of the production [€/y]	11280256
Declared revenue [€/y]	9585182
Main product	Ores
Estimated water consumption [m³/y]	846019
Estimated total water consumption of identified companies of the sector [m³/y]	846019

Electronics and optics - EO

- Total companies in the Pollino area: 1
- Total identified companies: none
- WUI: 5 L water / € production
- Cr pollution in wastewaters: neglectable

Due to the lack of data and small number of companies, this sector was neglected.

Clothing – CL

- Total companies in the Pollino area: 5
- Total identified companies: 1 (20%)
- WUI: 6 L water / € production
- Cr pollution in wastewaters: neglectable

Company name	G.P.S. MELE S.R.L.
Address	VIA VALLONCELLO 24
Industrial sector	CL
District	FRANCAVILLA IN SINNI - PZ
Employed	8
Share capital [€]	18000
Declared value of the production [€/y]	346548
Declared revenue [€/y]	346227
Main product	Clothing
Estimated water consumption [m³/y]	2079
Estimated total water consumption of identified companies of the sector [m³/y]	2079

Wood – WO

- Total companies in the Pollino area: 16
- Total identified companies: 3 (19%)
- WUI: 12 L water / € production
- Cr pollution in wastewaters: neglectable

Company name	EDIL LEGNO S.R.L.	ABILEGNO S.R.L.	ABITANTE POLICARPO & FIGLI S.R.L.
Address	CONTRADA S.ELANIA 20	CONTRADA PALOMBARA 18	VIA S.ELANIA 20
Industrial sector	WO	WO	WO
District	FRANCAVILLA IN SINNI - PZ	FRANCAVILLA IN SINNI - PZ	FRANCAVILLA IN SINNI - PZ
Employed	19	15	8
Share capital [€]	50000	50000	98800
Declared value of the production [€/y]	1468321	774425	190788
Declared revenue [€/y]	1354046	709115	188201
Main product	Wood	Wood elements	Wood
Estimated water consumption [m³/y]	17620	9293	2289
Estimated total water consumption of identified companies of the sector [m³/y]	29202		

Furniture – FU

- Total companies in the Pollino area: 2
- Total identified companies: 1 (50%)
- WUI: 6 L water / € production
- Cr pollution in wastewaters: neglectable

Company name	F.LLI MASTROLORENZO SRL
Address	VIA CARELLA 26/A
Industrial sector	FU
District	VIGGIANELLO - PZ
Employed	12
Share capital [€]	10000
Declared value of the production [€/y]	348494
Declared revenue [€/y]	355436
Main product	Furnitures (wood)
Estimated water consumption [m³/y]	2091
Estimated total water consumption of identified companies of the sector [m³/y]	2091

Beverages – BE

- Total companies in the Pollino area: 2
- Total identified companies: none
- WUI: 6 L water / € production
- Cr pollution in wastewaters: neglectable

Due to the lack of data, but in presence of a relevant number of small enterprises, mean values were estimated by national / other regional data. Since these companies are small, most probably they are specialized in natural spring water bottling.

In order to bottle 1m³ of water, 0.55 m³ of industrial water is required. Since these are small enterprises, their capacity was evaluated to be approx. 1000m³ bottled water per year each, and, as a consequence, the water consumption was estimated to be 0.6 m³ per year each.

Pharmaceutical - PH: 3

- Total companies in the Pollino area: 3
- Total identified companies: 3 (100%)
- WUI: 4 L water / € production
- Cr pollution in wastewaters: neglectable

Company name	EPIFARMA - SRL	PHARMEG S.R.L.	MERIDION PHARMA S.R.L.
Address	VIA S. ROCCO 6	VIA DEI GIARDINI 34	PIAZZA MAGISTRATI MAINIERI 14
Industrial sector	PH	PH	PH
District	EPISCOPIA - PZ	EPISCOPIA - PZ	FRANCAVILLA IN SINNI - PZ
Employed	15	6	5
Share capital [€]	81983	10000	5000
Declared value of the production [€/y]	5248416	167033	1101
Declared revenue [€/y]	4769566	2084	1101
Main product	Drugs	Drugs	Drugs
Estimated water consumption [m³/y]	20994	668	4
Estimated total water consumption of identified companies of the sector [m³/y]			21666

The obtained results from the data analysis is reported in Table 5.

Since not all companies in the Pollino area were identified, and we assume that the latter ones are small enterprises with less than 5 employees. In order to perform an estimation about their water consumption, two hypotheses were applied:

1. The unidentified companies have in average 3 employees
2. For the smallest identified company of the sector, the relevant number of employees (EI) and the water consumption (WIC) were considered. After this, water consumption (WUC) of the NUC (number of unidentified companies) small enterprises were calculated as follows:

$$WUC = 3 \times WIC \times EI^{-1} \times NUC$$

Based on the total water quantity consumption of every single industrial sector, the Cr pollution in the area was estimated as well.

Table 5: Results of the adopted industrial water consumption and Cr pollution procedure

SECTOR	ME	MA	TE	FO	MX	CL	WO	FU	BE	PH
TOTAL COMPANIES	40	5	4	26	15	5	16	2	4	3
TOTAL IDENTIFIED COMPANIES	0	3	2	5	1	1	3	1	0	3
IDENTIFICATION RATE	0%	60%	50%	19%	7%	20%	19%	50%	0%	100%
ESTIMATED TOTAL WATER CONSUMPTION OF THE IDENTIFIED COMPANIES [km³/y]	0.0	10.7	11.7	2.9	846.0	2.0	29.2	2.1	0.0	21.7
TOTAL UNIDENTIFIED COMPANIES	40	2	2	19	14	4	13	1	4	0
ESTIMATED TOTAL WATER CONSUMPTION OF UNIDENTIFIED COMPANIES [km³/y] (NOTE A)	1000.0	0.6	0.2	0.1	1974.0	3.1	11.0	0.5	2.4	0.0
ESTIMATED TOTAL WATER CONSUMPTION OF THE INDUSTRIAL SECTOR [km³/y]	1000.0	11.3	11.9	3.0	2418.1	5.1	40.2	2.6	2.4	21.7
ESTIMATED TOTAL WATER CONSUMPTION OF INDUSTRY [km³/y]	3516.3									
ESTIMATED PERCENTAGE WATER CONSUMPTION [%]	28.4	0.3	0.3	0.1	68.8	0.1	1.1	0.1	0.1	0.6
ESTIMATED PERCENTAGE WATER CONSUMPTION (BY PROCEDURE TABLE 4) [%] (NOTE B)	22.9	2.9	7.4	6.9	30.0	7.0	4.7	1.6	8.8	7.8
ESTIMATED TOTAL Cr POLLUTION [kg/y]	6.4	0	0	0	0	2.8	0	0	0	0

Note A: ESTIMATED TOTAL WATER CONSUMPTION OF UNIDENTIFIED COMPANIES was calculated as stated on pages 6, 11-12.

Note B: Industrial sectors "PC" and "EO" were neglected and percentage values evaluated again on all other industrial sectors.

Comparing the obtained results in Table 5 with those reported in Table 4, it is interesting to notice that it was possible to estimate the same total water consumption in the Pollino area ($3505.1 \text{ km}^3/\text{y}$ vs $3516.3 \text{ km}^3/\text{y}$), and corresponds to other available data sources.

On the other hand, the industry of the Pollino area has a particular footprint that differs much with that on average national level (Table 4). Indeed, it appears that mineral extraction and manufacturing is the main (historical) activity in the area, and this industrial structure was maintained, mostly at family driven companies' level. Clothing, that appears to be the third major industry of the region, may have profited from the presence of Cr salts available by the steel industry. Other industries exhibits sensibly lower water usage footprints, established in a second time profiting of to the particular nature of the region (food and wood industry), nowadays near a national natural park, leading to a "green" industry. As ease of an example, the BE industry is mainly focused on mineral water bottling (that has an average industrial water consumption much lower than soda or other product production) or the PH industry is focused on limited and specific "natural drugs" production, that do not require chemical synthesis (and, as a consequence, high water amounts).

Concerning Cr contamination, it was estimated that industry disperse to the environment approx.. $10 \text{ kg}/\text{y}$, that should be considered a considerable pollution amount of this heavy metal, that should not be allowed. On the other side, it appears that this amount has little influence of the typical Cr pollution observed in the area (soil, groundwater, superficial aquifers), that cannot be justified by only by the industrial activity and, therefore, its source should be identified elsewhere.