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Assessment of the health impact of the industrial emissions in the environmental management of the "**Taranto Case**"

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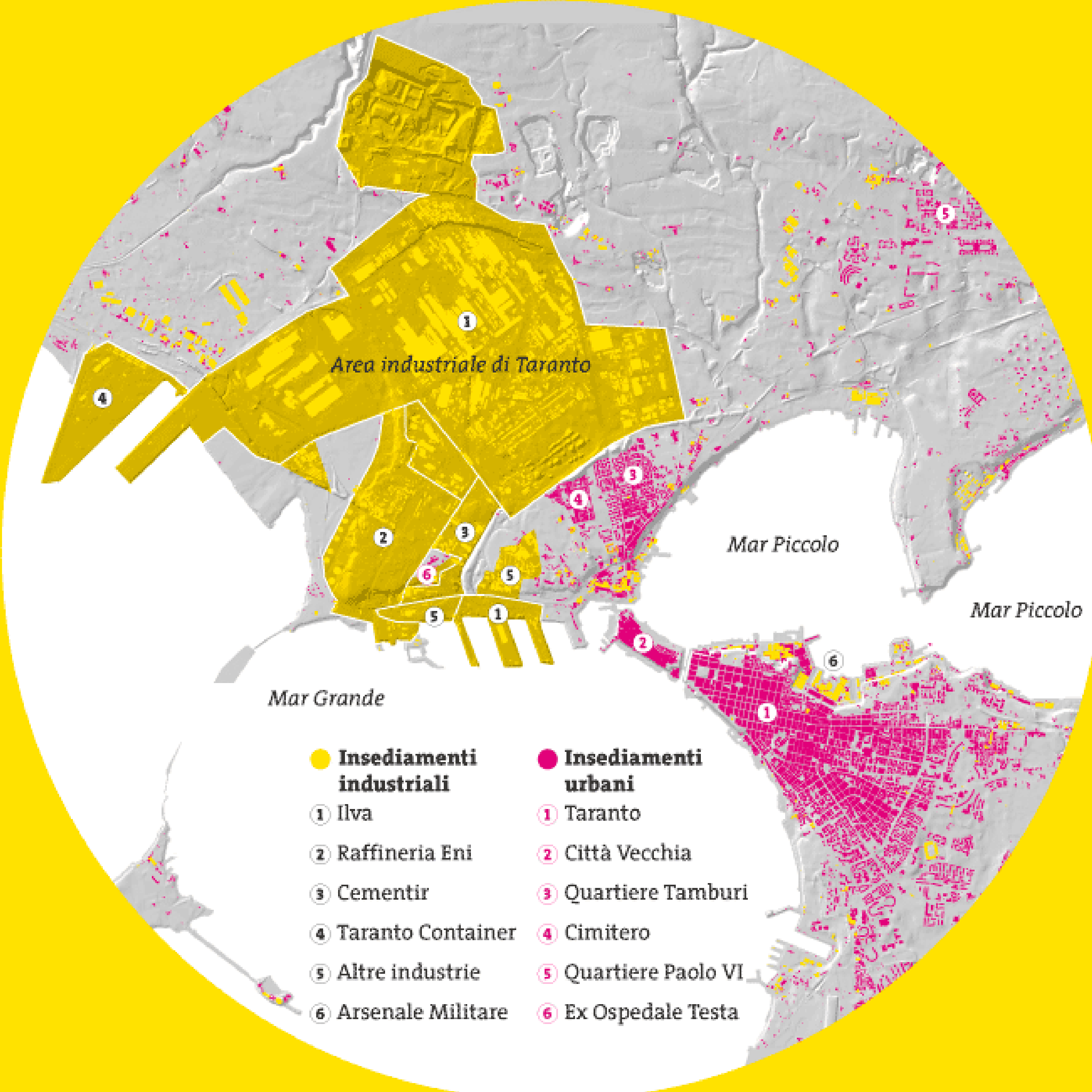
COST Action TD1105, Rome 4 - 6 december 2012

TARANTO (Pop. 192,810), Apulia, S Italy, on the Gulf of Taranto, an arm of the Ionian Sea.

Taranto is the chief military port of Italy. It is also an industrial, and fishing center. Productions include steel, metal products, refined petroleum, cement, machinery, and ships.

Founded by the Spartans, according to tradition (8th century BC.) ,it became one of the most prosperous cities in Magna Græcia. (Great Greece), and is now site of several historical tourist attractions, including a national museum, a theater etc.

It was built up on the extreme eastern side of the Isthmus, which was joined to the Peninsula Salentina continent, on the coastal road along Mare Grande (Big Sea) and an ample lagoon called Mare Piccolo (Small Sea) (that’s why Taranto is named “the City with Two Seas”).


Area industriale di Taranto
Mar Piccolo
Mar Piccolo
Mar Grande
Insediamenti industriali
1 Ilva
2 Raffineria Eni
3 Cementir
4 Taranto Container
5 Altre industrie
6 Arsenale Militare
Insediamenti urbani
1 Taranto
2 Città Vecchia
3 Quartiere Tamburi
4 Cimitero
5 Quartiere Paolo VI
6 Ex Ospedale Testa

The Taranto area (Southern Italy) hosts several industrial facilities including thermal/combustion processes with remarkably high raw materials and high energy demand and known potential sources of PCDD/Fs and PCBs release to air, land, and water. These facilities include a large integrated steel plant **(1)**, a medium-sized oil refinery **(2)**, a large cement-works **(3)**, two power plants (4,5), and three waste incinerators (6,7,8) as well as a large naval base with military shipyards **(9)**.

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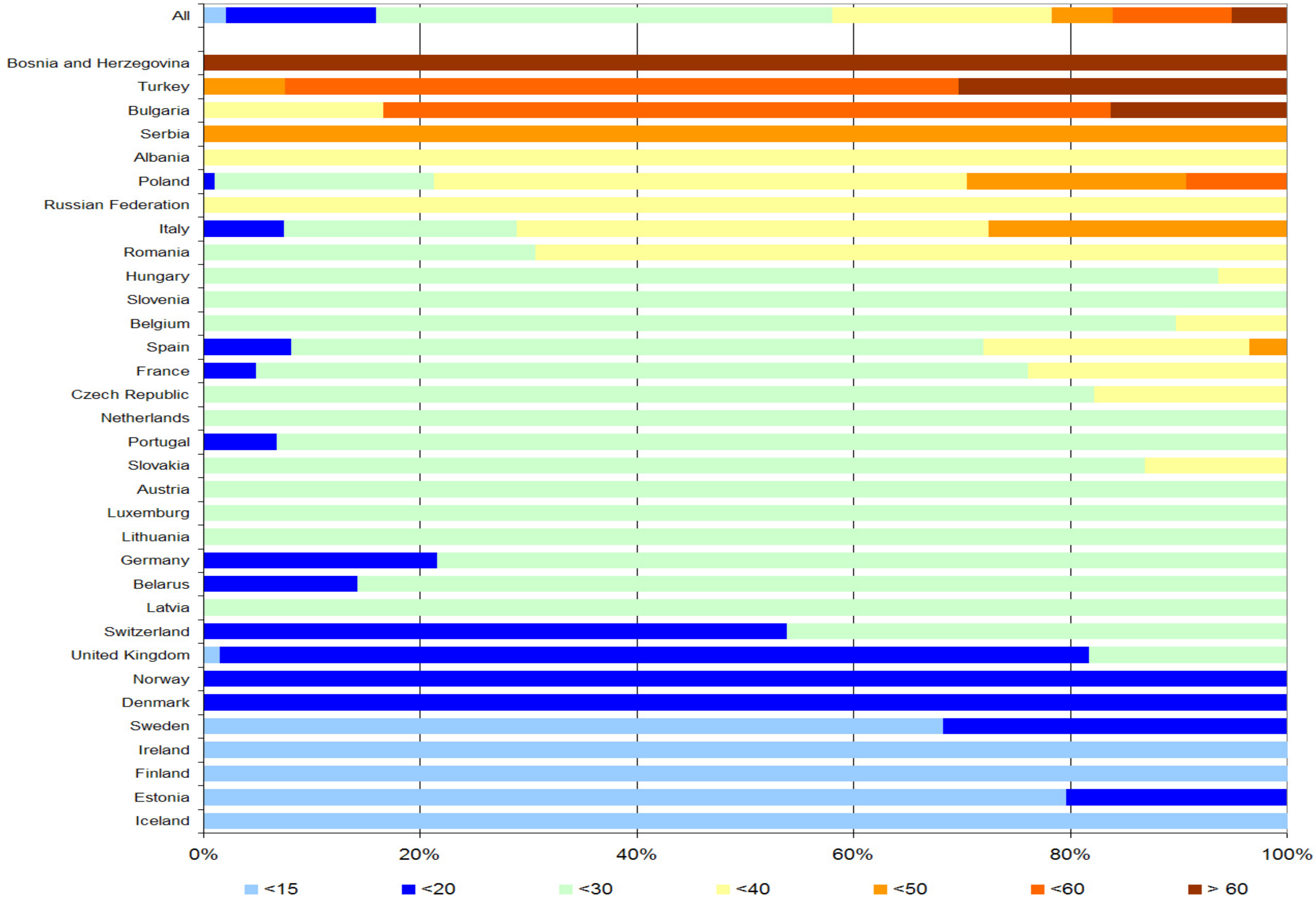
Refinery
Integrated steel plant

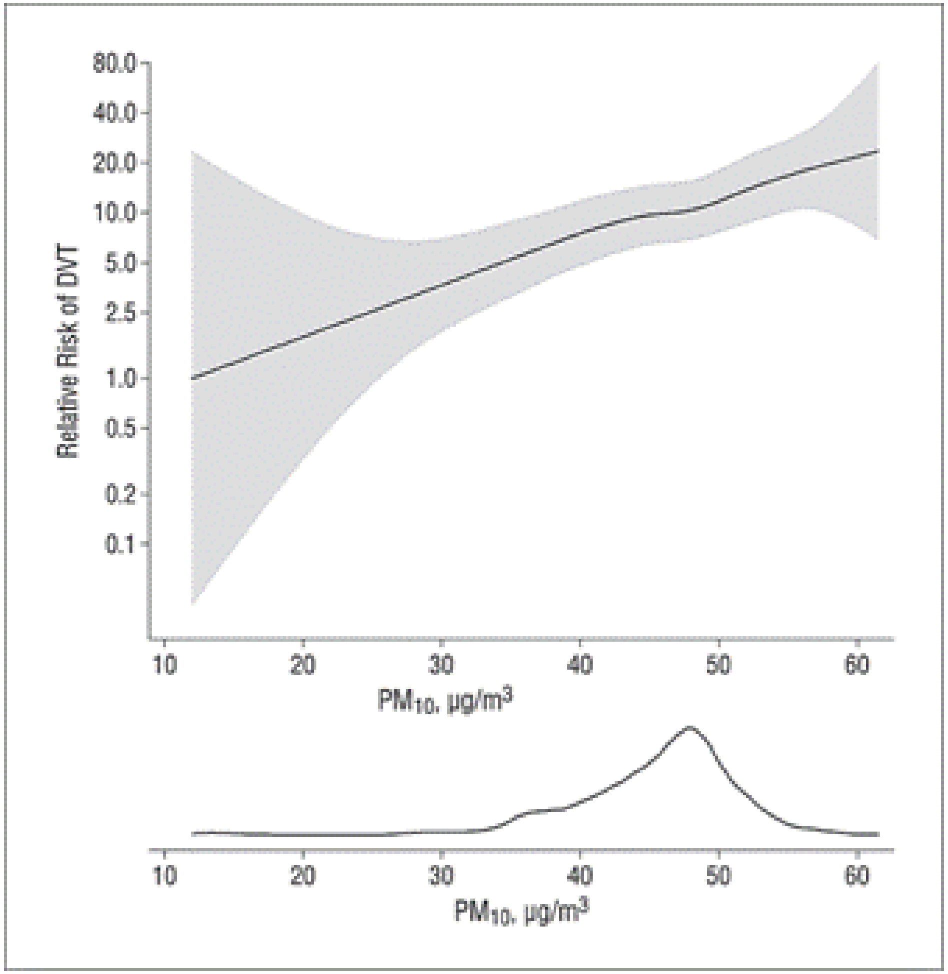
Particulate matter Guideline values

PM2.5
10 µg/m3 annual mean
25 µg/m3 24-hour mean
PM10
20 µg/m3 annual mean
50 µg/m3 24-hour mean

The 2005 AQG set for the first time a guideline value for particulate matter (PM). The aim is to achieve the lowest concentrations possible. As no threshold for PM has been identified below which no damage to health is observed, the recommended value should represent an acceptable and achievable objective to minimize health effects in the context of local constraints, capabilities and public health priorities.

Fig.1. Percentage of people living in cities with various PM10 levels in µg/m3, 2009





EXPOSURE TO PARTICULATE AIR POLLUTION AND RISK OF DEEP VEIN THROMBOSIS
Baccarelli A, Martinelli I, Zanobetti A, et al.
Arch Intern Med 2008; 168:920-927

CONCENTRATION-RESPONSE FACTORS FOR HUMAN HEALTH EFFECTS ASSOCIATED WITH PM10

Annual risk factor given a 1 ug/m3 change in annual average PM10 concentration:

Mortality risk: 1.80E-05

Chronic bronchitis risk: 6.10E-05 *[for population 25 years and older]*

Respiratory hospital admissions: 8.40E-06

Cardiac hospital admissions: 3.00E-06

Emergency room visits: 2.40E-04

Asthma symptom days: 5.80E-02 *[for 4.7% of population with asthma]*

Restricted activity days: 5.80E-02 *[for population 18 years and older]*

Department of Health

Investigating the Health Impact of Emissions to Air from Local Industry

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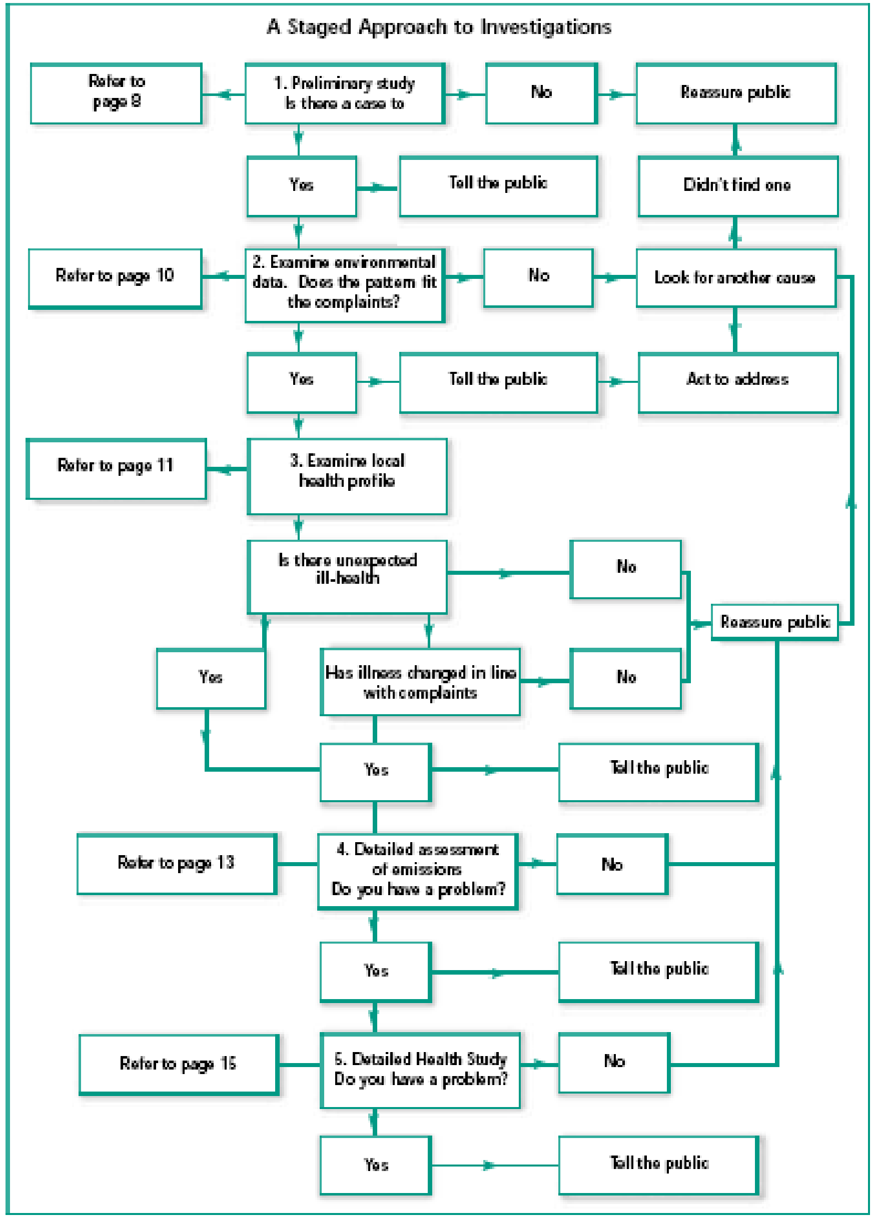

A Staged Approach to Investigations
Refer to page 8
1. Preliminary study
Is there a case to
No
Reassure public
Yes
Tell the public
Didn't find one
Refer to page 10
2. Examine environmental data. Does the pattern fit the complaints?
No
Look for another cause
Yes
Tell the public
Act to address
Refer to page 11
3. Examine local health profile
Is there unexpected ill-health
No
Reassure public
Yes
Has illness changed in line with complaints
No
Yes
Tell the public
Refer to page 13
4. Detailed assessment of emissions
Do you have a problem?
No
Yes
Tell the public
Refer to page 15
5. Detailed Health Study
Do you have a problem?
No
Yes
Tell the public

Orru H, Teinemaa E, Lai T, Tamm T, Kaasik M, Kimmel V, Kangur K, Merisalu E, Forsberg B.

Health impact assessment of particulate pollution in Tallinn using fine spatial resolution and modeling techniques.

Environmental Health. 2009;8:7

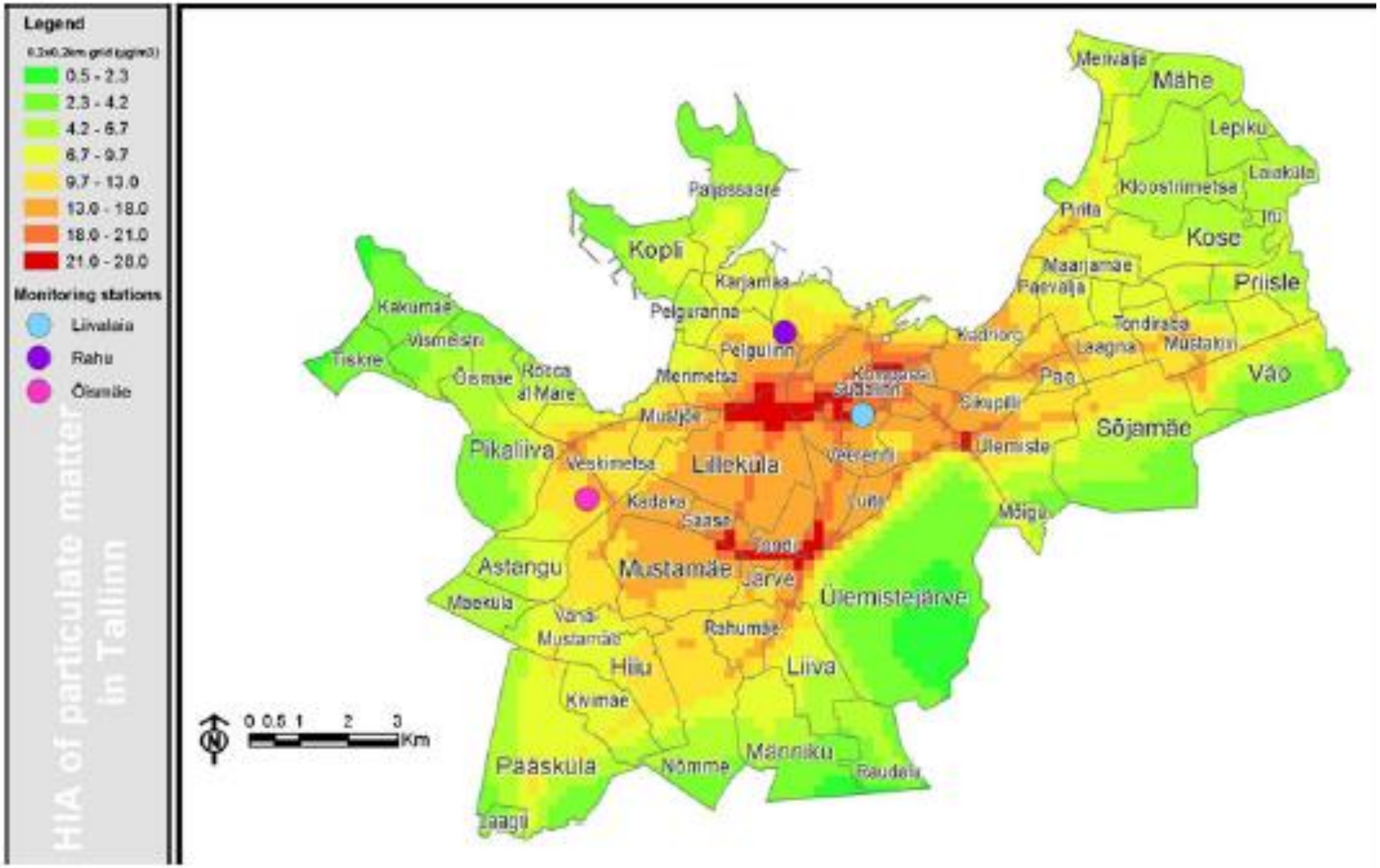
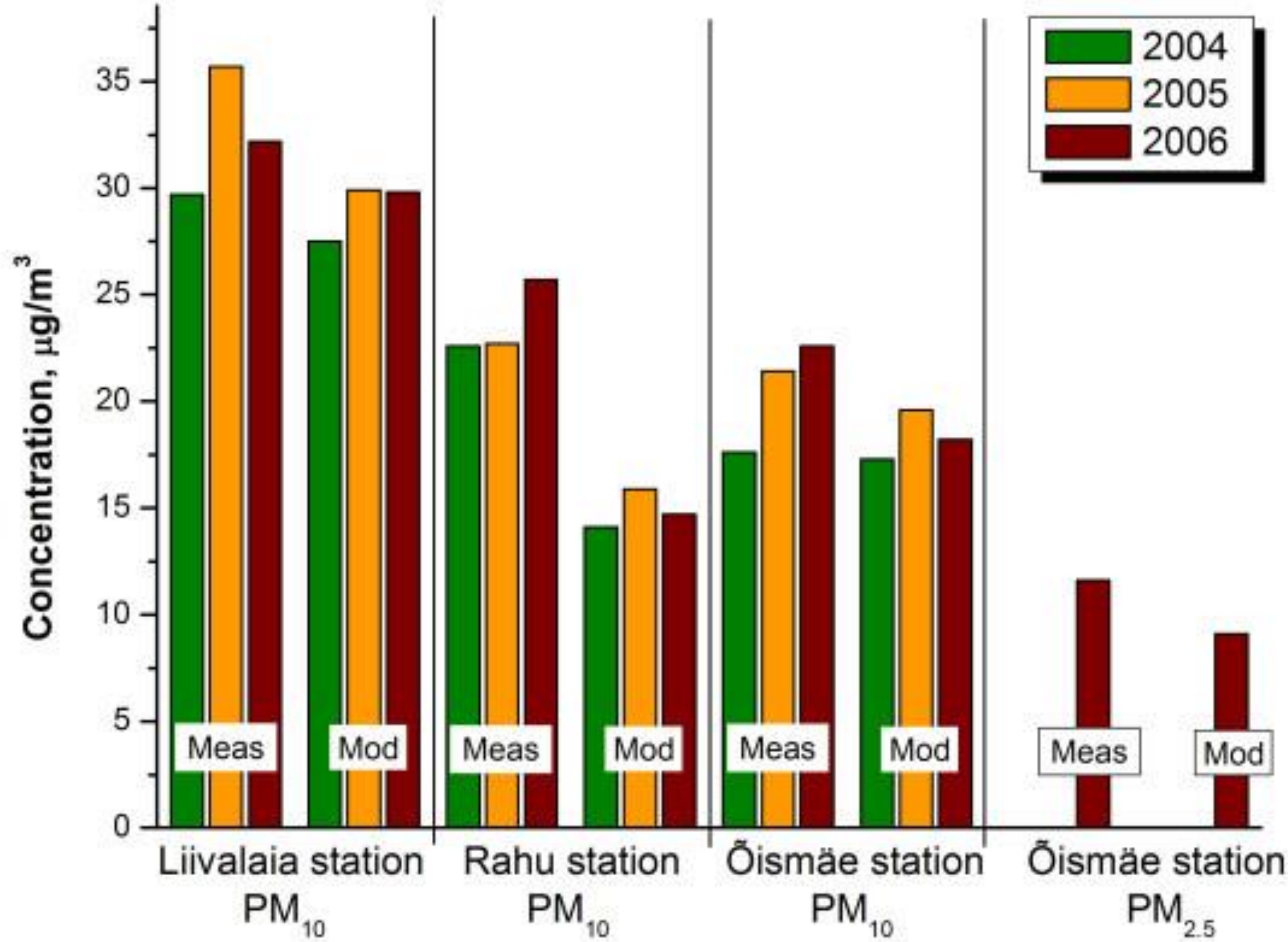


Figure 1

Modeled (200 × 200 m grid) annual average concentration of $PM_{2.5}$ in Tallinn, $\mu g/m^3$.

The number of premature death due to PM2.5 pollution in Tallinn

City district	Number of population	Annual exposure to local PM2.5 (µg/m3)	Number of Premature deaths (95% CI)	Number of premature deaths 1/1000 (95% CI)	The loss of life expectancy in years (95% CI)
Haabersti	38 031	9.5	23 (6–42)	0.60 (0.16–1.10)	0.52 (0.14–0.90)
Mustamäe	62 589	14.0	63 (16–112)	1.01 (0.26–1.79)	0.78 (0.20–1.34)
Nõmme	38 268	7.2	18 (5–31)	1.01 (0.26–1.79)	0.78 (0.20–1.34)
Kesklinn	47 105	17.1	51 (13–91)	1.08 (0.28–1.93)	0.94 (0.25–1.62)
Kristiine	28 878	16.2	30 (8–54)	1.04(0.28–1.87)	0.89 (0.24–1.53)
Lasnamäe	107 280	10.2	73 (19–131)	0.68 (0.18–1.22)	0.56 (0.15–0.97)
Pirita	13 192	6.4	5 (1–8)	0.38 (0.08–0.61)	0.36 (0.09–0.61)
Põhja-Tallinn	53 621	9.3	33 (9–59)	0.62 (0.17–1.10)	0.52 (0.14–0.89)
TOTAL	**388 964**	**11.6**	**296 (76–528)**	**0.76 (0.20–1.36)**	**0.64 (0.17–1.10)**



Concentration, μg/m3
0
5
10
15
20
25
30
35
2004
2005
2006
Meas
Mod
Meas
Mod
Meas
Mod
Meas
Mod
Liivalaia station PM10
Rahu station PM10
Õismäe station PM10
Õismäe station PM2.5

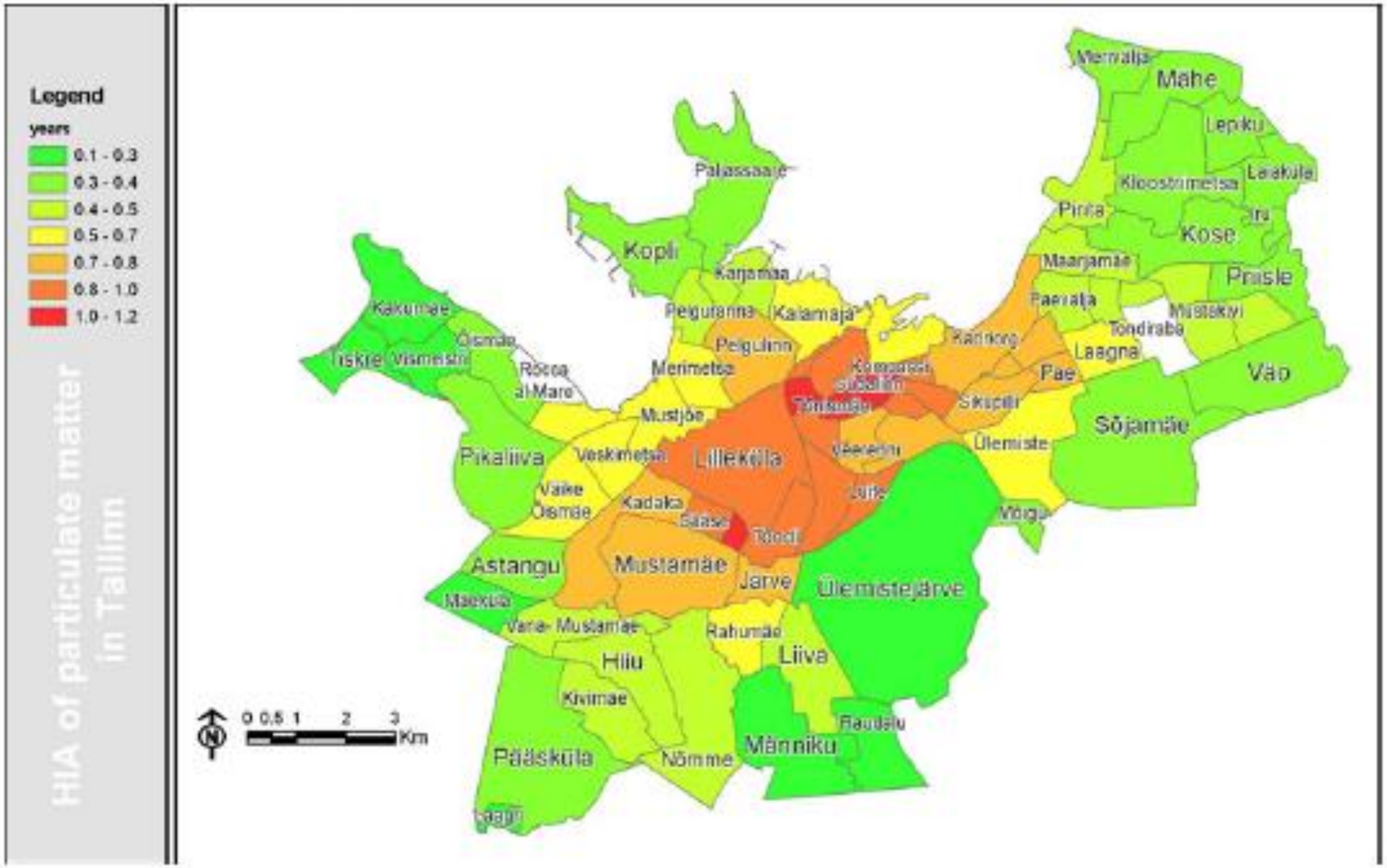


Figure 4
Decrease of life-expectancy due to $PM_{2.5}$ pollution in Tallinn.

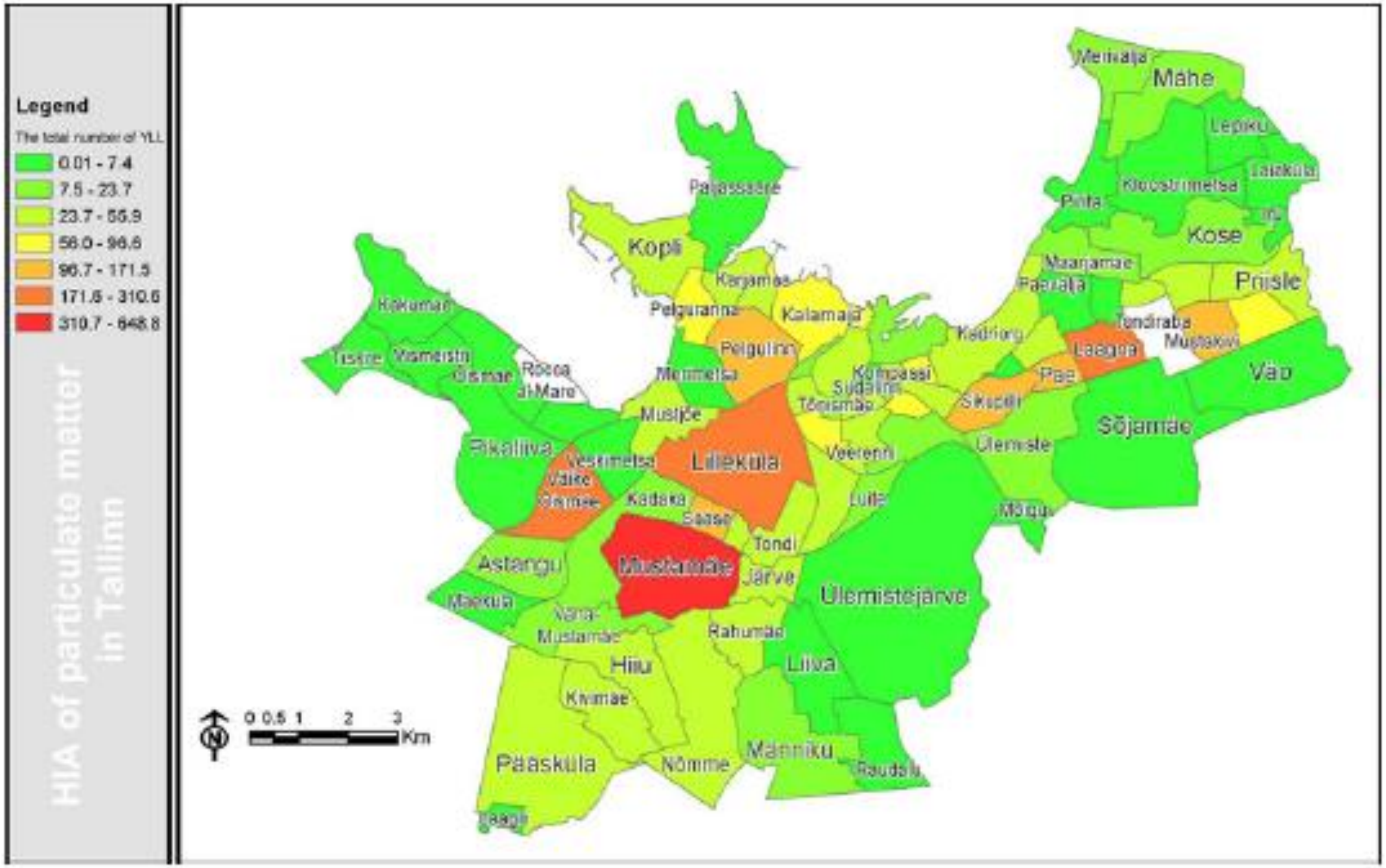


Figure 3

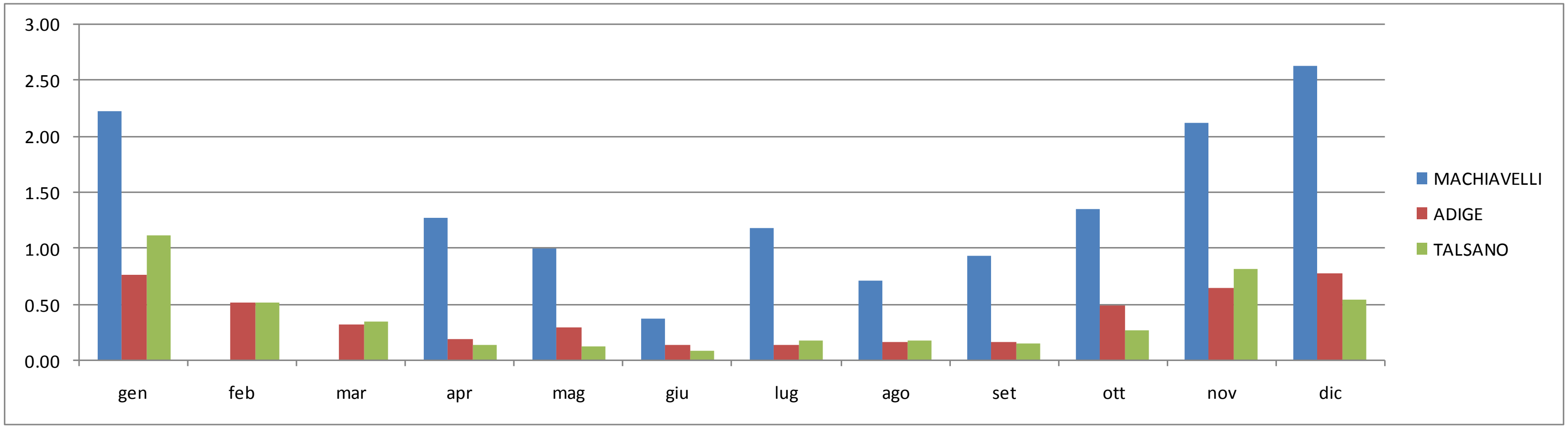
The total number of YLL due to $PM_{2.5}$ pollution in Tallinn.

Benzo[a]pirene Rilevation- 2009

Medie aritmetiche e pesate dei valori di concentrazione mensile di b(a)p in ng/mc nei 3 siti di Taranto

VIA MACHIAVELLI	VIA ALTO ADIGE	TALSANO
media pesata	*media pesata*	*media pesata*
1.31	*0.36*	*0.35*
media aritmetica	*media aritmetica*	*media aritmetica*
1.39	*0.39*	*0.38*

Andamento mensile di concentrazione di benzo(a)pirene



Estimate of cancer risk

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- BaP in class 1/ARC – carcinogenic for humans
- Uncertainty about the quantitative estimate and the risk and the dose-response relationship
- **PAHs** are a mixture, which the different components have different potential carcinogen, **BaP** used as a substance index
- Revision of estimates available in the literature:

Table 12. Summary of unit risk estimates for B[*a*]P and for PAHs with B[*a*]P as the indicator substance (life-time risk per ng/m^3 of B[*a*]P).

Basis for calculation	Unit risk	Reference
Animal experiments		
Inhalation of B[*a*]P in hamsters (Thyssen et al. 1981)	0.28×10^{-6} [a]	RIVM (1989)
Inhalation of B[*a*]P in hamsters (Thyssen et al. 1981)	$0.37–1.7 \times 10^{-6}$ [b]	CARB (1994); Collins et al. (1991); Muller (1997)
Inhalation of B[*a*]P + SO_2 in rats (Laskin et al. 1970 cit. RIVM 1989)	0.59×10^{-6} [a]	RIVM (1989)
Inhalation of B[*a*]P in mice (Knizhikow et al. 1982 cit. RIVM 1989)	400×10^{-6} [a]	RIVM (1989)
Intratracheal instillation of B[*a*]P in hamsters		
Saffiotti et al. (1972)	4.4×10^{-6} [b]	CARB (1994); Collins et al. (1991)
Feron et al. (1973)	4.8×10^{-6} [b]	CARB (1994); Collins et al. (1991)
Inhalation of coal tar/pitch aerosol with B[*a*]P as the indicator substance	20×10^{-6} [b]	Heinrich et al. (1994)
Epidemiology (PAH with B[*a*]P as indicator)		
U.S. coke-oven workers	87×10^{-6}	WHO (1987, 2000)
U.S. coke-oven workers	23×10^{-6}	Muller (1997)
U.S. coke-oven workers	50×10^{-6}	Pott (1985)
U.K. gas workers	430×10^{-6}	Pike (1983)
Smoky coal indoors in China	67×10^{-6}	RIVM (1989)
Most appropriate estimate	100×10^{-6}	RIVM (1989)
Aluminum smelters	90×10^{-6}	Armstrong et al. (1994); converted from workplace exposure to continuous lifetime exposure

[a]Linear extrapolation. [b]Linearized multistage model.

Estimation of B(a)P related carcinogenic risk

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Estimated health impact on the population of the district-TamburiLido Azzurro in Taranto

Starting from the average concentration of BaP detected at the site of via Machiavelli in Taranto in 2010 (1.82 ng/m3) and using the unit risk value indicated by the WHO (8.7 x 10-5 to 1 ng/m3 BaP), an incremental risk was estimated being equal to:

Incremental Lifetime Cancer Risk = 8.7 x 10^{-5} (ng/m^3) x 1.82(ng/m^3) = 15.8 x 10^{-5}

Estimated excess of cases of lung cancer in the population of the district-Tamburi Lido Azzurro (17,644 inhabitants on April 9, 2009) due to a lifetime exposure at the measured level of BaP, is equal to:

15.8 x 10^{-5} x 17644 = 2.79 cancers

Estimate of cancer risk

US –EPA considers excess cancer risks that are below about 1 chance in 1,000,000 (1×10^{-6} or 1E-06) to be so small as to be negligible, and risks above 1E-04 to be sufficiently large that some sort of remediation is desirable

Risk Assessment Guidance for Superfund, 1989

Figure 2-1. Risk Assessment Approach

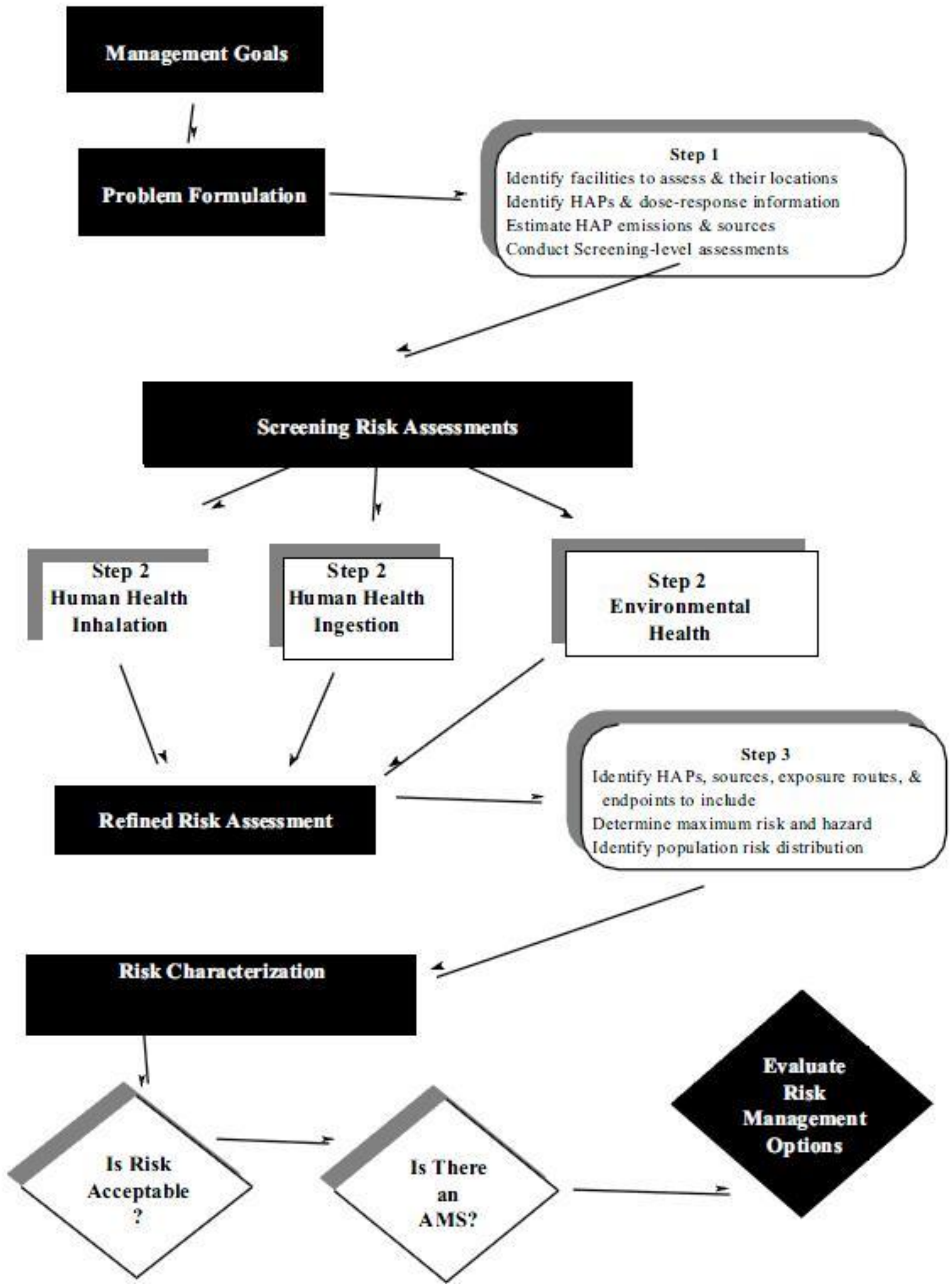


Table 3-3. Summary of Cancer Risk Assessment Screening Analysis

Constituent	AK Steel Middletown	AK Steel Ashland	Erie Coke	Tonawanda
Benzo(a)pyrene	$2x10^{-10}$	$4x10^{-9}$	$2x10^{-10}$	$2x10^{-10}$
Benzo(a)anthracene	$2x10^{-10}$	$4x10^{-9}$	$3x10^{-10}$	$2x10^{-11}$
Benzene	$2x10^{-5}$	$5x10^{-4}$	$7x10^{-6}$	$5x10^{-5}$
Benzene soluble organics	$5x10^{-5}$	$8x10^{-4}$	$2x10^{-4}$	$1x10^{-4}$
Benzo(b)fluoranthene	$2x10^{-10}$	$4x10^{-9}$	$2x10^{-10}$	$4x10^{-11}$
Benzo(k)fluoranthene	$1x10^{-10}$	$2x10^{-9}$	$2x10^{-10}$	$2x10^{-13}$
Chrysene	$6x10^{-11}$	$1x10^{-9}$	$7x10^{-11}$	$6x10^{-12}$
Nickel	$2x10^{-9}$	$4x10^{-8}$	$3x10^{-9}$	$6x10^{-10}$
Arsenic	$3x10^{-8}$	$6x10^{-7}$	$3x10^{-8}$	$2x10^{-8}$
Beryllium	$5x10^{-10}$	$1x10^{-8}$	$6x10^{-10}$	$1x10^{-10}$
Cadmium	$2x10^{-9}$	$4x10^{-8}$	$2x10^{-9}$	$9x10^{-10}$
Total	$7x10^{-5}$	$1x10^{-3}$	$2x10^{-4}$	$2x10^{-4}$

Table 3-10. Inhalation Cancer Risk and Hazard Quotient for Exposed Population

Site	Facility-Level Maximum Risk [a]	Hazard Quotient
AK Steel–Middletown	$5x10^{-5}$	NI[b]
AK Steel–Ashland	$5x10^{-4}$	Benzene → 0.4
		Arsenic →0.07
Erie Coke	$1x10^{-4}$	NI
Tonawanda	$1x10^{-4}$	NI

[a] Maximum risk at 70 year exposure duration

[b] NI = not included in analysis

Results reflect exposure from all emission sources, (i.e., MACT I, MACTII, and the By-Product Recovery Plant)

Figure 3-1 Cancer Risk Isopleths Around AK-Steel Middletown

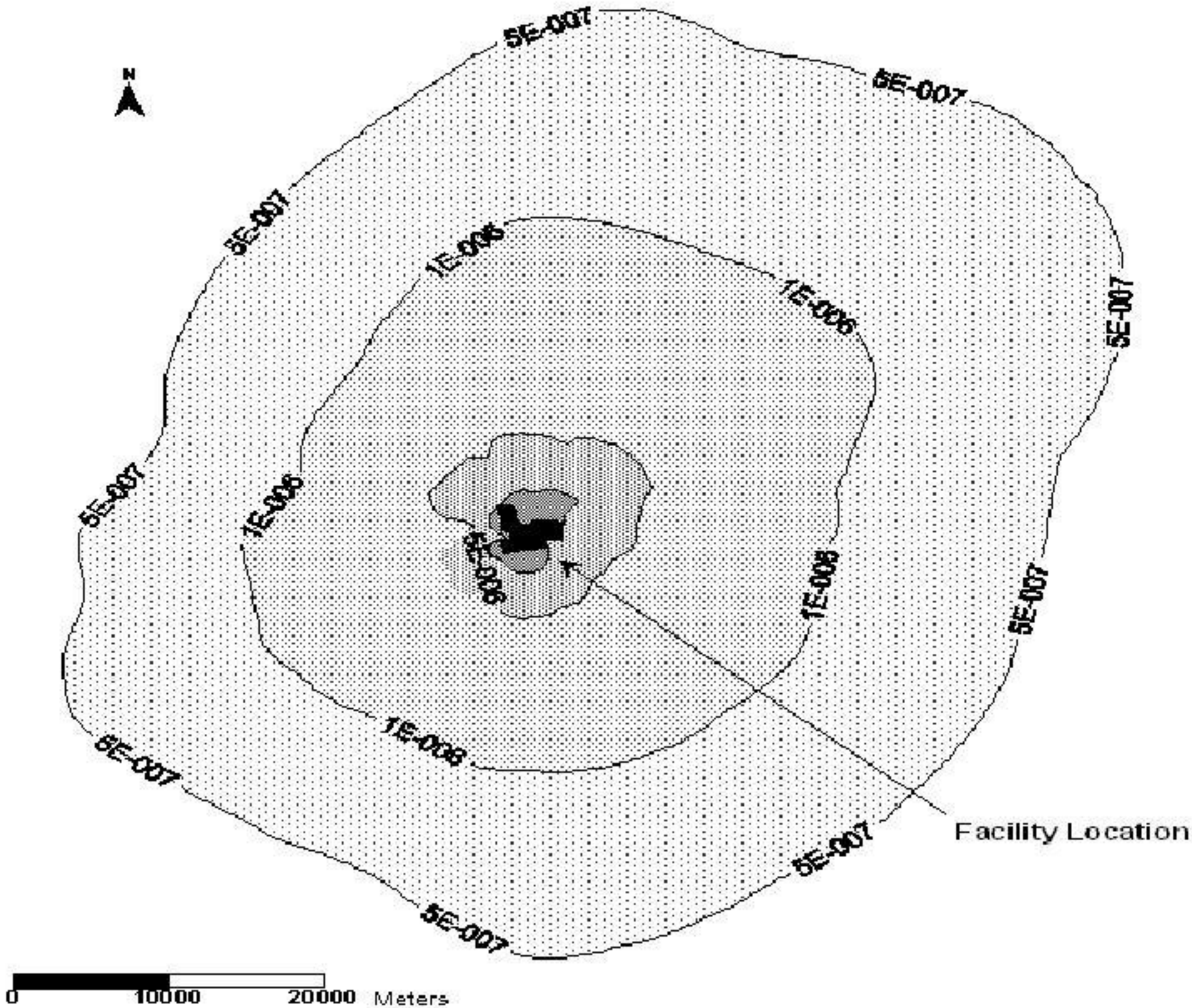


Figure 3-2 Cancer Risk Isopleths Around AK-Steel Ashland

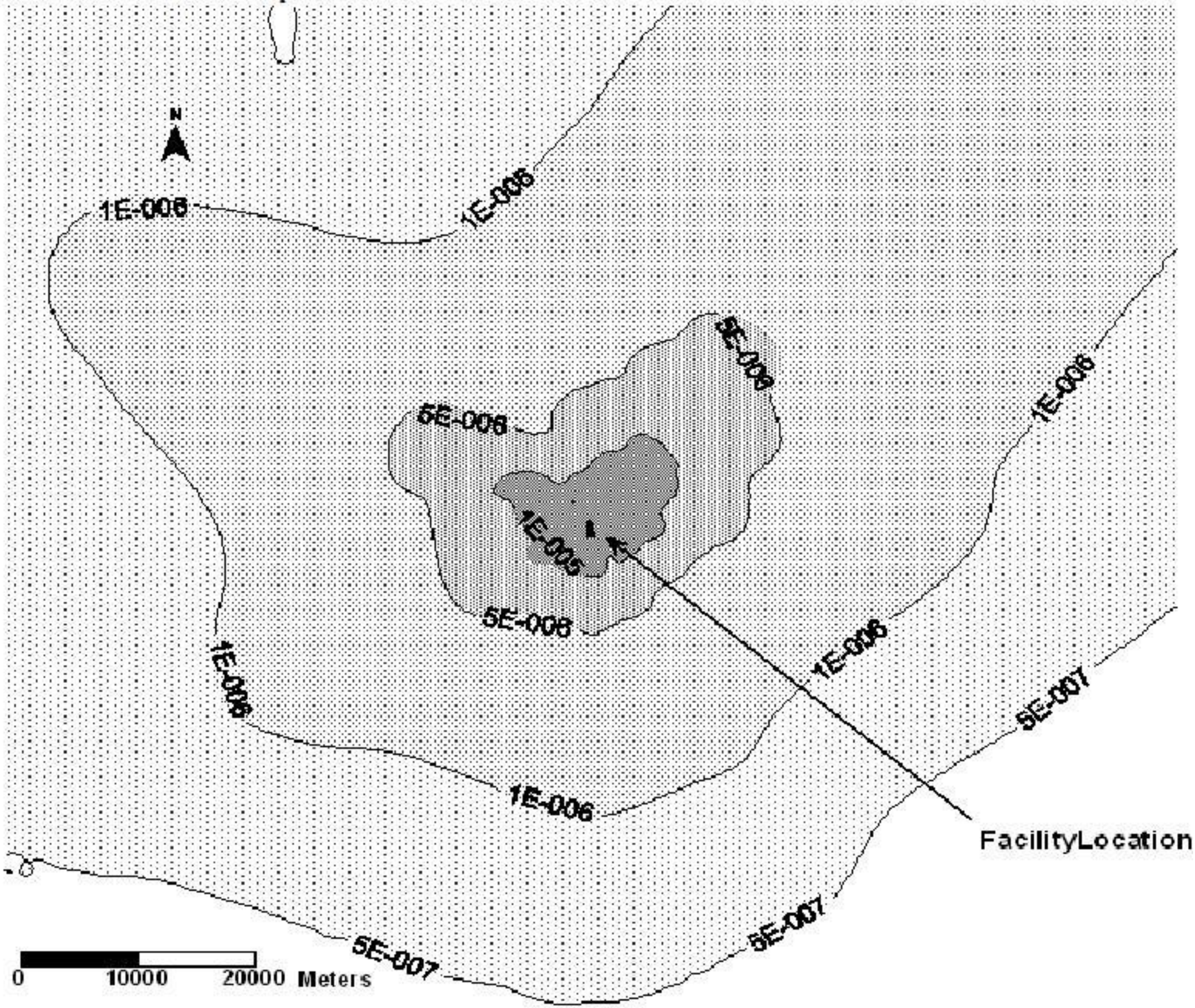


Figure 3-3 Cancer Risk Isopleths Around Erie Coke

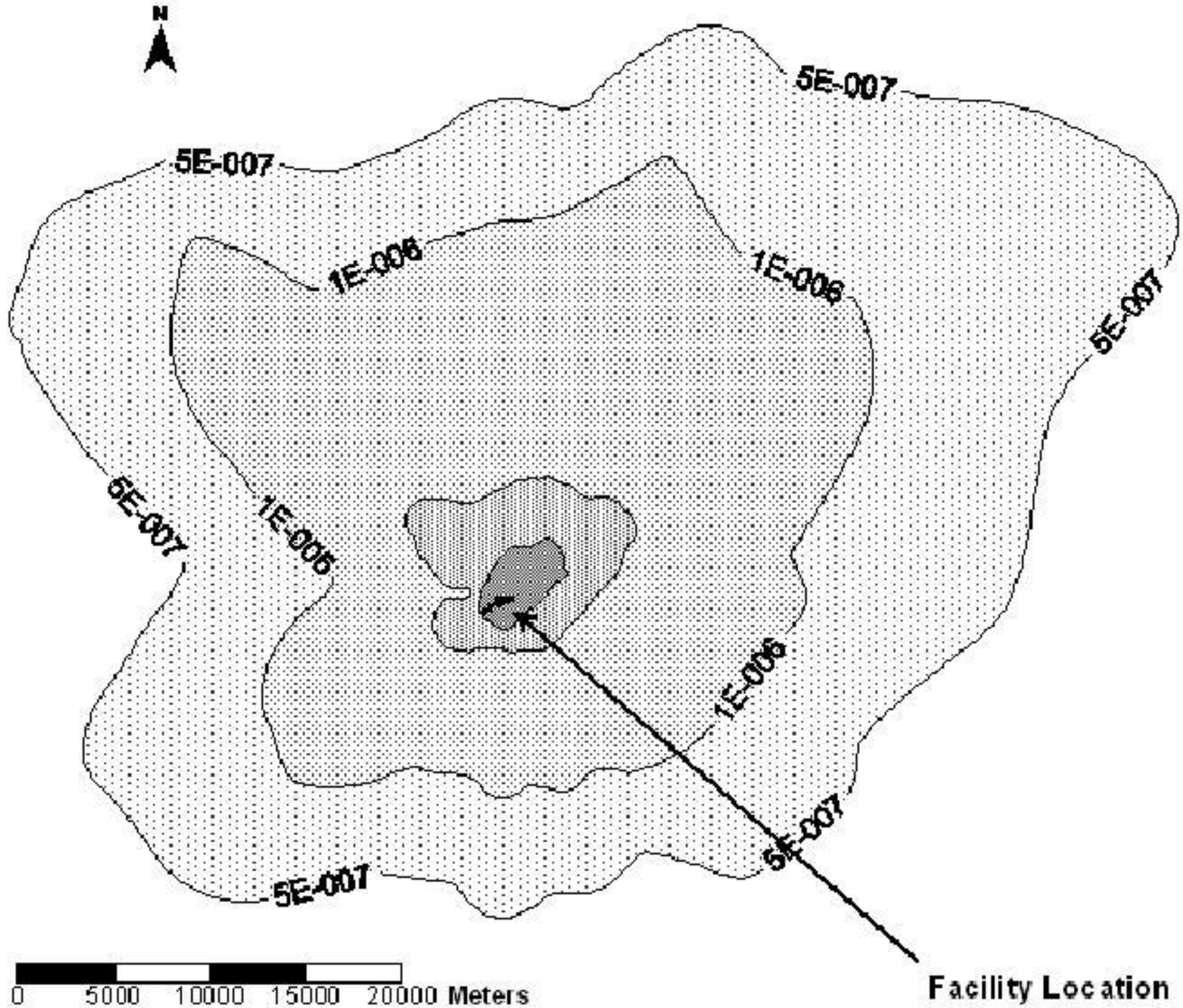
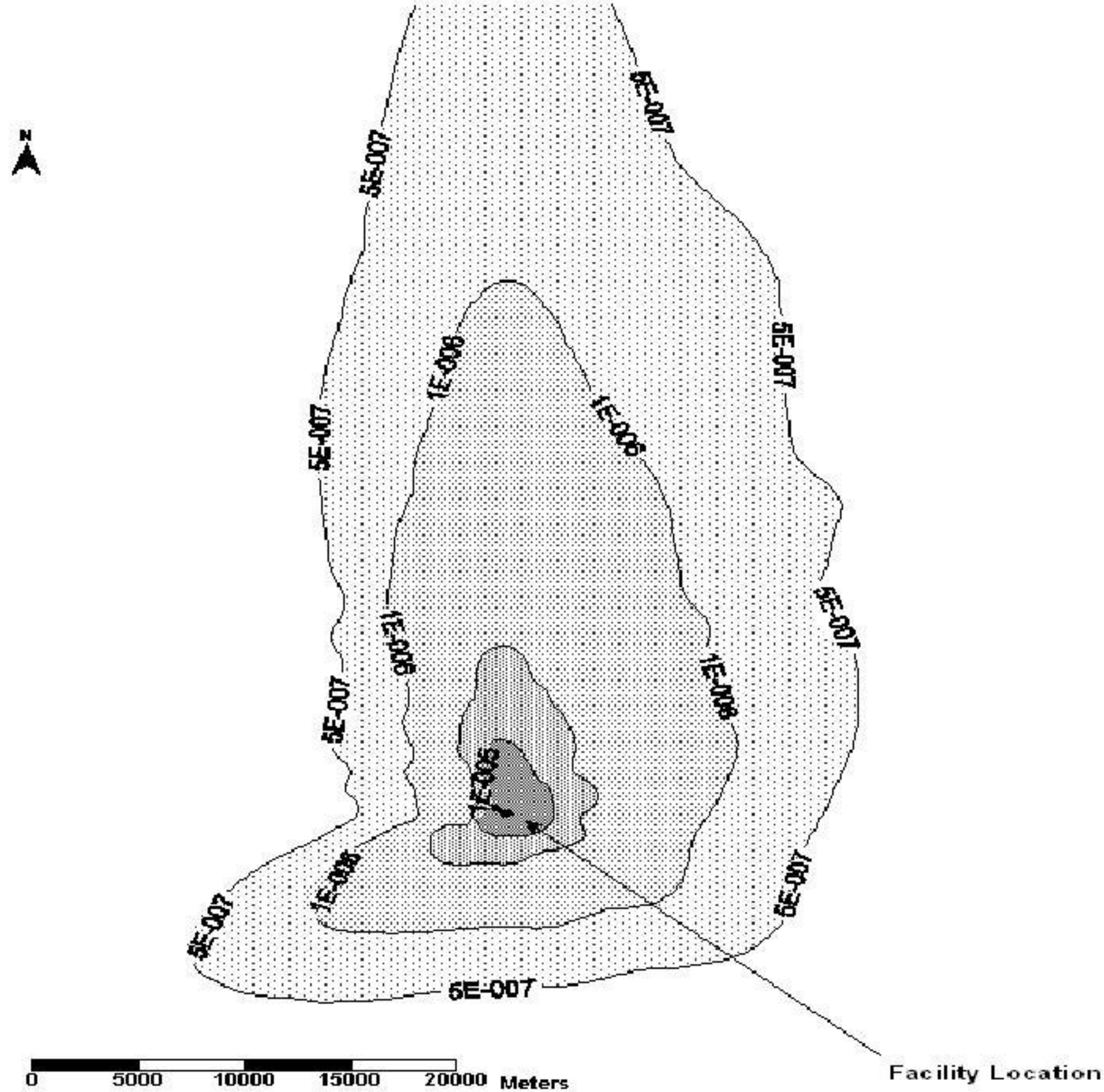


Figure 3-4 Cancer Risk Isopleths Around Tonawanda Coke



Simulation of PM10 concentration of industry and residents

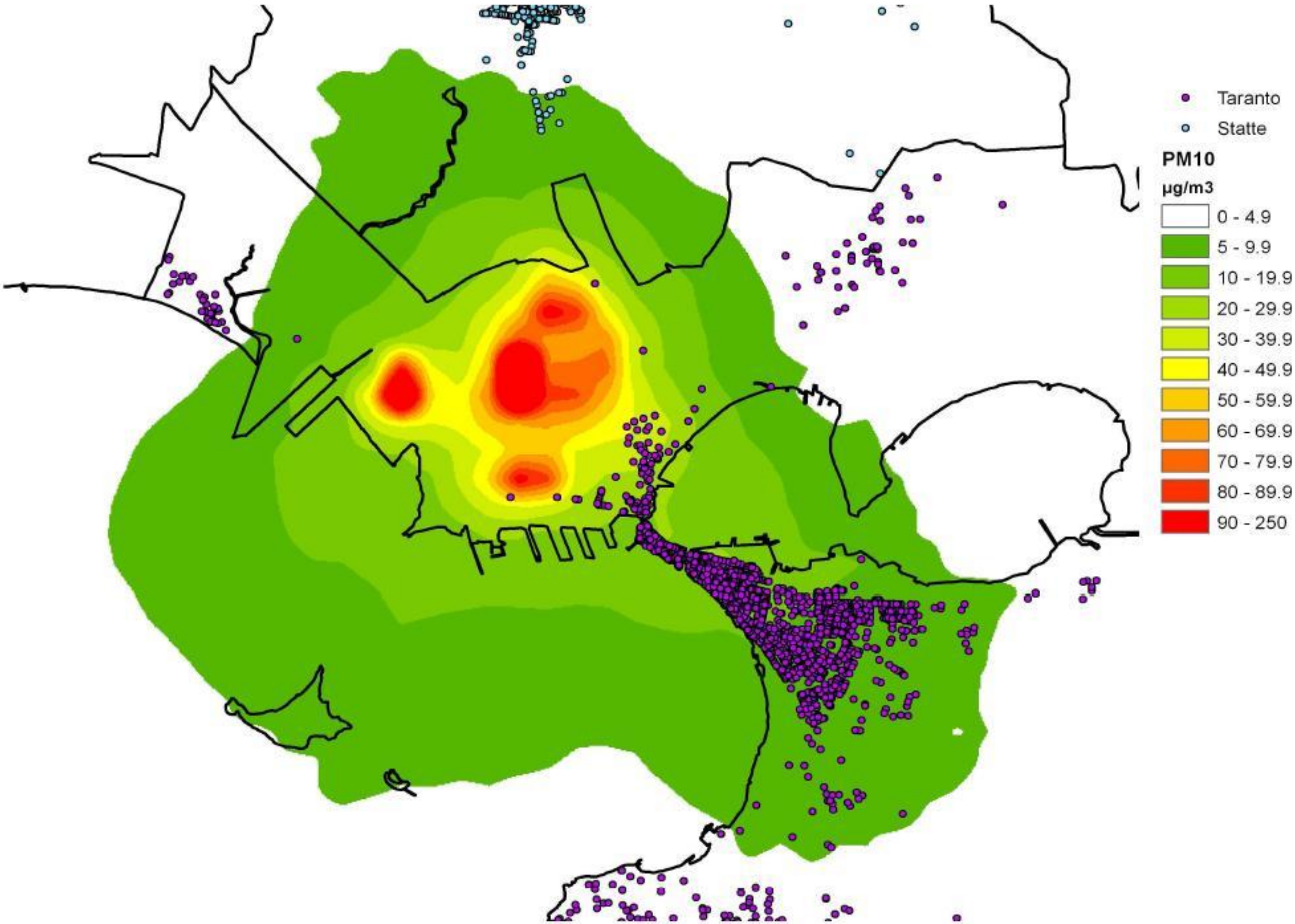


Tabella 13. Associazione tra esposizione a polveri inquinanti (PM_{10} proveniente dalla zona industriale) e mortalità per causa. Rischio relativo per 10 ° g/m^3 PM_{10}

Causa (ICD-9-CM)	Maschi*			Femmine**		
	HR	Low	Up	HR	Low	Up
Tutte le cause (001-999)	**1,02**	**1,00**	**1,05**	**1,01**	**0,99**	**1,03**
Cause naturali (001-799)	**1,03**	**1,00**	**1,05**	1,00	0,98	1,02
Tumori maligni (140-208)	1,01	0,97	1,05	0,98	0,94	1,01
Esofago (150)	1,38	0,95	2,02	0,73	0,41	1,31
Stomaco (151)	1,03	0,87	1,22	1,07	0,93	1,23
Colon retto (153-154)	0,85	0,72	1,00	0,90	0,80	1,00
Fegato e dotti biliari (155-156)	0,84	0,71	0,99	0,99	0,89	1,10
Pancreas (157)	1,15	0,95	1,39	1,02	0,89	1,16
Laringe (161)	0,87	0,64	1,17			
Trachea, bronchi e polmoni (162)	1,02	0,95	1,09	0,97	0,85	1,10
Pleura (163)	1,12	0,90	1,38	1,00	0,73	1,37
Connettivo e tessuti molli (171)	**1,53**	**1,01**	**2,31**	0,80	0,48	1,34
Mammella (174)				1,04	0,96	1,13
Prostata (185)	**1,14**	**1,01**	**1,28**			
Testicolo (186)	0,56	0,16	1,97			
Vescica (188)	1,00	0,86	1,15	1,12	0,91	1,38
Rene (189)	0,98	0,64	1,50	0,78	0,44	1,39
Encefalo ed altri tumori del SNC (191-192; 225)	1,08	0,88	1,33	0,83	0,68	1,01
Tessuto linfatico ed ematopoietico (200-208)	1,05	0,91	1,22	0,90	0,80	1,02
Linfomi non-Hodgkin (200-202)	1,09	0,86	1,39	0,90	0,73	1,11
Leucemie (204-208)	1,04	0,81	1,33	0,94	0,77	1,15
Malattie neurologiche (330-349)	1,05	0,91	1,22	**1,09**	**1,00**	**1,19**
Morbo di Parkinson (332)	1,12	0,83	1,50	0,90	0,69	1,17
Malattie cardiovascolari (390-459)	1,01	0,97	1,05	1,01	0,98	1,03
Malattie cardiache (390-429)	**1,02**	**0,98**	**1,07**	**1,05**	**1,01**	**1,08**
Malattie ischemiche del cuore (410-414)	**1,06**	**0,99**	**1,14**	**1,11**	**1,06**	**1,18**
Eventi coronarici acuti (410-411)	1,06	0,96	1,18	**1,11**	**1,02**	**1,20**
Malattie cerebro-vascolari (430-438)	0,96	0,88	1,05	0,90	0,85	0,95
Malattie apparato respiratorio (460-519)	0,97	0,90	1,04	1,00	0,94	1,07
Infezioni delle vie respiratorie (460-466,480-487)	0,91	0,77	1,07	0,95	0,85	1,06
BPCO (490-492, 494, 496)	0,97	0,89	1,06	1,02	0,93	1,11
Malattie apparato digerente (520-579)	1,04	0,96	1,13	0,97	0,90	1,03
Malattie renale (580-599)	1,10	0,95	1,29	**1,10**	**1,00**	**1,22**

Association between primary industrial PM10 and hospital cases. Relative risk by 10 μg/cubic meter

		MALES			FEMALES		
		HR	LOW	UP	HR	LOW	UP
Pop AGE 0-14							
cancer	(140-208)	1,25	0,91	1,71	1,27	0,89	1,80
diseases of the respiratory tract	(460-519)	1,09	1,05	1,12	1,09	1,05	1,13
respiratory tract infections	(460-466,480-487)	1,12	1,08	1,16	1,12	1,07	1,17
Asthma	(493)	0,79	0,62	1,02	0,70	0,49	1,00

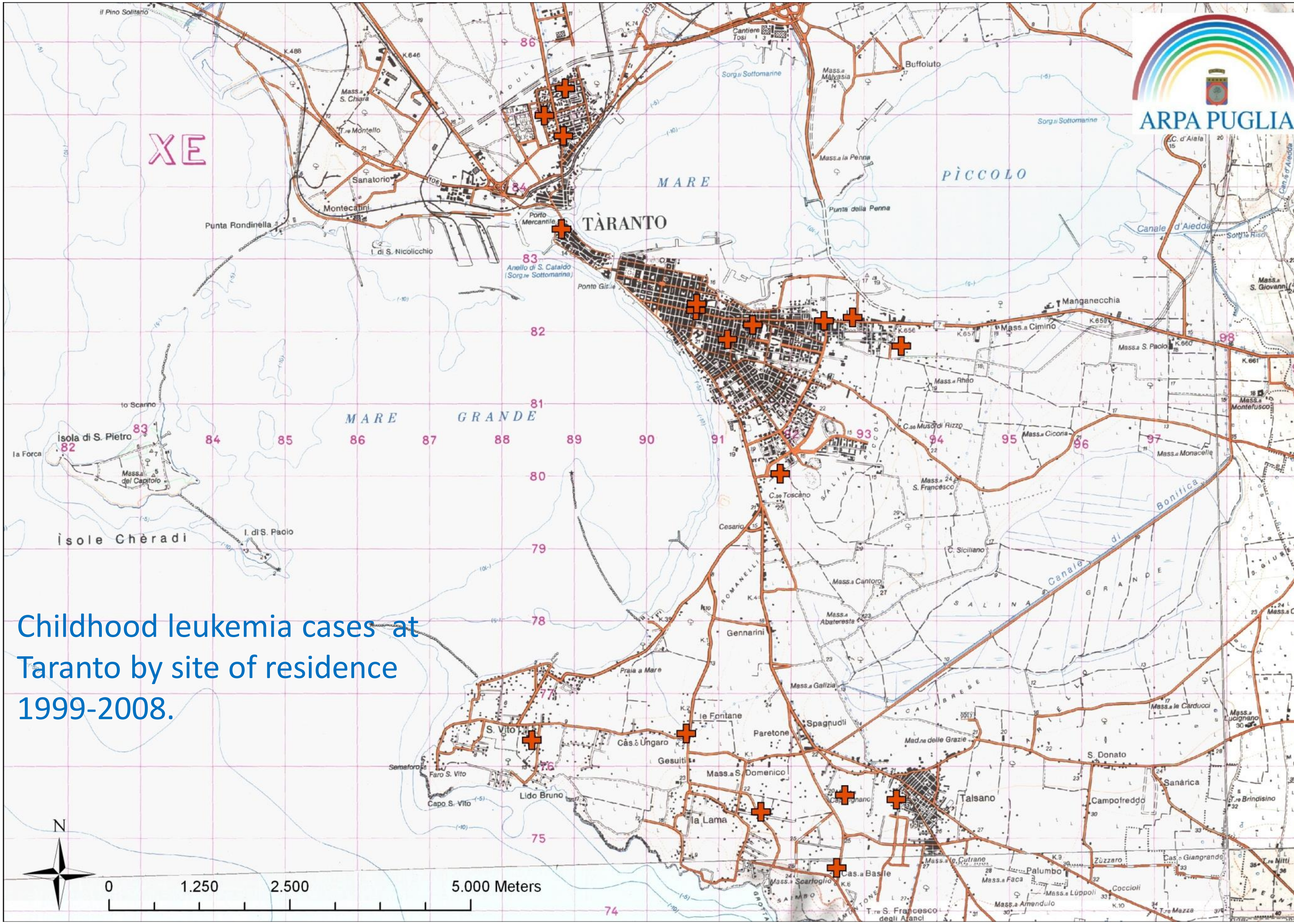
Forastiere et al.2012

Hazard Ratio (HR), Cox model stratified by follow-up period, adjusted by age and socioeconomic status

Number of attributable cases (and AR%) to industrial primary PM10for hospital cases (1998-2010)

		Total cases	Attributable cases	95% CI	AR %
Pop AGE 0-14					
cancer	(140-208)	89	17	0-35	19.5
diseases of the respiratory tract	(460-519)	8769	638	456-820	7.3
respiratory tract infections	(460-466,480-487)	6281	627	478-776	10.0

Forastiere et al.2012



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Childhood leukemia cases at Taranto by site of residence 1999-2008.

Environment and Health in Taranto : a proposal of ARPA Puglia and ASL to national department of Environment during the IPPC process

1. **Source apportionment of atmospheric PM10 PM2.5 and its deposition;**

2. **Biomonitoring of PAH and heavy metal exposure in general population of Taranto, at different distance from industrial area;**

3. **Short-term effects of pollution on human health;**

4. **Long-term effects of pollution on human health;**

5. **Case-control study on non Hodgkin lymphomas, soft tissue sarcomas and exposure to PCDD/Fs and PCB.**


foto n. 22 CTU

Grazie per l’attenzione