Emerging Compounds in water intended for human consumption: experiences and evolution

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Emerging Compounds (ECs) or Emerging Pollutants

According to US EPA, **Emerging pollutants** are "new chemicals without regulatory status and whose impact on environment and human health are understood".

Pharmaceuticals And Personal Care Products

Prescription and OTC (over-the-counter) medicines

- Analgesics
- Antidepressants
- Blood pressure drugs

Food and beverage ingredients

- Acesulfame (sweetener)
- Caffeine
- Theobromine (chocolate)

Drugs of abuse

- Morphine
- Nicotine

Veterinary medicines

- Antibiotics
- Hormones

PCP (Personal Care Product) ingredients

- Fragrances
- DEET (diethyltoluamide = insect repellent)
- Triclosan

Health care facilities

- Analgesics
- Antibiotics
- Chemotherapy agents
- X-ray contrast agents

Endocrine Disrupting Compound (EDC)
ED (Endocrine Disrupter)

Substance or mixture of substances of exogenous origin that may alter the normal functionality of the endocrine system and consequently cause negative effects on human (or animal) health and/or descendants

Historic example

- **DES** (diethylsilbestrol): in the 50s and 60s it was prescribed to pregnant women to prevent spontaneous abortion
  - ✓ Effects on progeny
  - ✓ Deformity of different kind
  - ✓ In women: vaginal cancer on the occurring of puberty

Endocrine Disrupting Compounds

- Natural hormones produced by a species but that may show macro-effects on other species (e.g.: human hormones, present in discharged waste water, that may have negative effects on fish)
- Chemical substances of natural origin (toxins, fungi, phytoestrogens)
- Synthetic drugs with a high hormone concentration (contraceptives, anti-cancer drugs)
- Final and by-products of synthetic origin (DDT, chlorinated compounds, additives for plastics, PCBs, nonylphenol)

Endocrine Disrupting Compounds

Natural and medicinal hormones
- Estradiol
- Estrone
- Ethinylestradiol

Plasticizers
- Bisphenol A
- Phthalates

Pesticides
- Atrazine
- Metolachlor

Surfactants
- 4-Nonylphenol
- Octylphenol

Flame retardants and coatings
- PFOS/ PFOA (perfluoroocatanoic derivatives)
- TBEP/ TCEP (organophosphates)

Sunscreens and lotions
- DEET (diethyltoluamide = insect repellent)
- Octyl methoxy cinnamate
- Triclosan

HOW CAN EMERGING POLLUTANTS BE REMOVED?

Most DWTPs/WWTPs currently operating were not designed to remove emerging pollutants. Nevertheless good yields can be obtained for some classes:

- Estrogens: 60 – 95%
- Alkylphenols: 60 – 90%
- Drugs: scattered values (from 0% for chloroderivatives up to 95% in some other cases)

HOW CAN EMERGING POLLUTANTS BE REMOVED?

Generally speaking:

- GAC filtration, to remove hydrophobic substances
- Oxidation processes, to remove substances with active functional groups (-NH_2, -OH) in benzene rings. Particularly effective are the so called AOPs (Advanced Oxidation Processes) such as: UV/H_2O_2, UV/O_3, H_2O_2/O_3
- Membrane filtration (physical barriers), the highest yields being obtained with nanofiltration and reverse osmosis

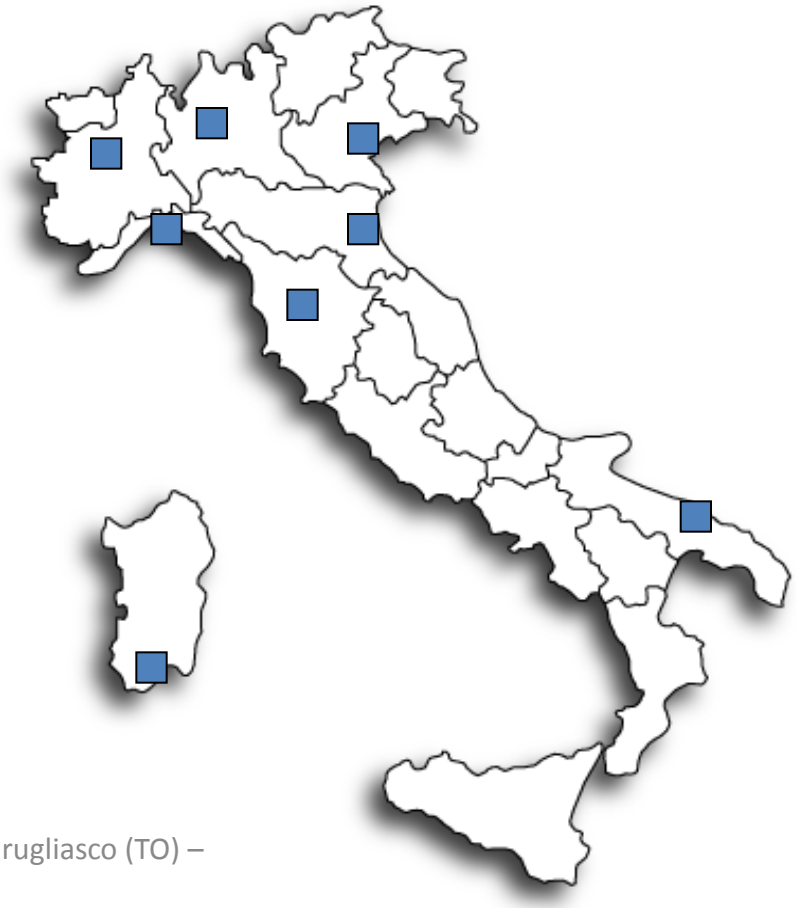
Research on Emerging Compounds (particularly on EDCs) in Italy

From year 2008 to year 2011 a project on EDCs has been successfully carried out with the aim of:

- Studying the impact of EDCs on water used for production and distribution of drinking water in Italy
- Promoting interactions between water companies and research institutes to set up reference laboratories on EDCs in Italy
- Developing and validating analytical methods for the determination of EDs in water, in the framework of D. Lgs. 31/2001 (Transposition of Drinking Water Directive 98/83/CE)
- Evaluating bioassay tests and comparison with chemical methods
- Analysing case studies representing different real situations (especially surface waters with different impacts) to help water companies verify the effectiveness of their treatment plants and evaluate possible weak points

Fondazione AMGA in collaboration with the National Institute of Health in Italy has promoted and financially supported this research project directly involving some Italian Water Companies for Sampling & Extraction of samples:

- Mediterranea delle Acque S.p.A. – Genoa
- SMAT S.p.A. – Turin
- ACSM Reti Gas Acqua srl – Como
- VERITAS S.p.A. – Venice
- Publiacqua S.p.A. - Florence
- Hera S.p.A. - Bologna
- Acquedotto Pugliese S.p.A. - Bari
- ABBANOA S.p.A. - Cagliari



Fondazione AMGA

- Management, Financing and Benchmark

University of Genoa

- E-SCREEN - a biological test for the evaluation of estrogenic activity through assay.
- Use of a biological test for the assessment of the genotoxic potential of water containing Endocrine Disrupters.
- Sampling & analysis (POCIS)

University of Pisa

- Short-term *in vitro* biological test using a recombinant yeast - *S. cerevisiae* RMY326

University of Trento

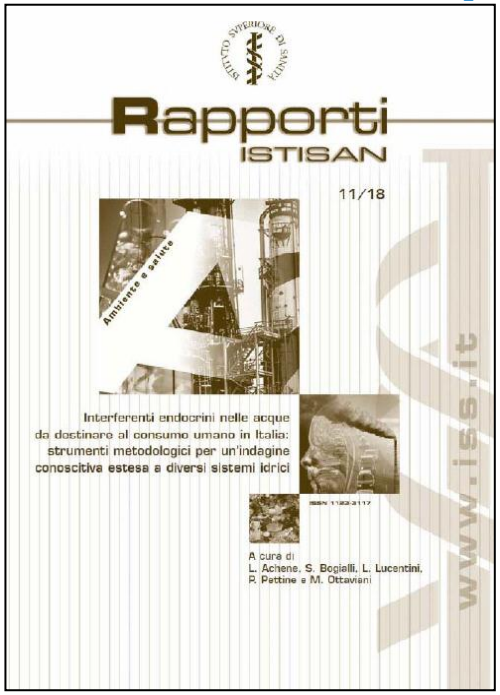
- Case studies, Water treatment

National Institute of Health Rome

- Development of analytical methods & QA/QC
- Data assessment

THE PROJECT – PUBLICATIONS

www.iss.it/binary/publ/cont/11_18_



This volume illustrates and comments the results of the survey. It also summarizes key information on the possible presence of Endocrine Disrupters in the integrated water cycle (particularly in water intended for human consumption) and current positions in the management of the problem.

www.fondazioneamga.org/ita/convegni.asp

Project Conclusion

Surface waters are the most easily contaminated in terms of EDCs (origin: wastewater, leachate from landfills, water from cultivated fields or cattle raising).
Some potabilisation treatments may be effective in EDCs removal.
So far the concentrations of EDCs detected in water for human consumption don't seem to pose a risk for consumers, but adequate Water Safety Plans should be adopted.

Future perspective

Since the most likely source of contamination of surface water comes from contact with wastewater, it was decided to launch a further investigation on the presence of these substances in WWTP effluents.
Inclusion of new compounds as Perfluorinated Carboxylic Acids and Diclofenac (non-steroidal anti-inflammatory drug), following the decision of the EC of including it in the priority list.

Emerging Compounds in Europe – state of the art

WssTP (Water supply and sanitation Technology Platform) **is the European Technology Platform for Water**. Initiated by the European Commission in 2004, it promotes coordination and collaboration of Research and Innovation in the European water sector, improving same time its competitiveness. **WssTP consists of 145 members** and a network of more than 700 individuals from Industry, research, technology providers, policy makers and water users.

Working Group on Emerging Compounds - led by Deltares (Utrecht, NL)
Objective:

- To exchange information between scientists, practitioners, policy makers, SMEs and industries and NGOs on scientific and technological developments in tackling the challenges of emerging compounds
- To develop a research and innovation agenda and to provide input in national and European research and innovation programmes (including JPI-water, Horizon2020).
- To create an efficient link between the WssTP and future EIP (European Innovation Partnership) Action Groups on related topics.
- To facilitate joint research and innovation activities through linking national projects and collaborating in international consortia.

Working Group on Emerging Compounds

TOPICS:

1. Identification, Emissions and Monitoring
2. Methods for Treatment and Removal
3. Behaviour, Fate and Transport in the aquatic environment and urban water cycle
4. Impacts on ecosystems, ecosystem services and human health
5. Modelling and Information Systems
6. Strategies for risk assessment, control and mitigation
7. Social aspects related to PPCPs

Currently Fondazione AMGA is the leader of **Topic 4**, which investigates on

Impacts on ecosystems, ecosystem services and human health

- Development of field-based assessments as well as lab based tests.
- Assessment of the bio-availability of emerging compounds in the aquatic environment
- Impacts of a cocktail of emerging compounds on aquatic ecosystems, ecosystem services and human health

Working Group on Emerging Compounds

NEXT EVENTS

Brokerage event on Emerging Compounds:
Bruxelles, 23rd and 24th November 2015
(programme still not available)

Workshop of the WG on November 25th, 2015 in Bruxelles

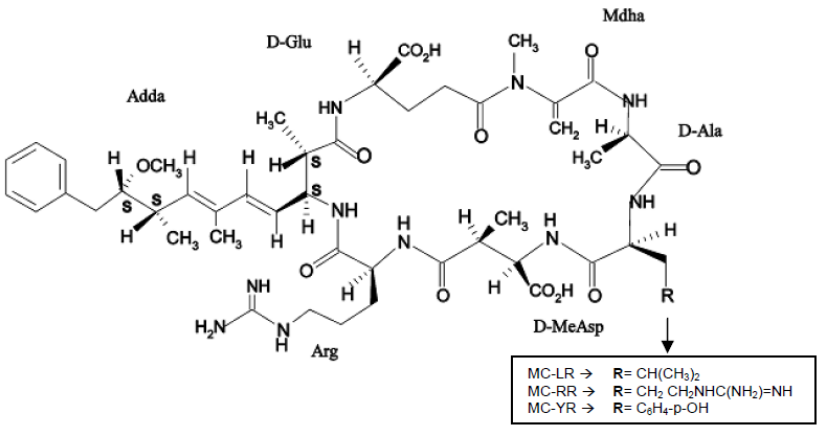
- Questionnaires sent last May to companies and institutions for mapping activities on ECs in Europe
- Answers and results to be discussed

Algal mycrotoxins in water for human consumption

This project is focused on reviewing and sharing analytical techniques currently used and on monitoring the levels of algal microtoxins in the waters of natural or artificial basins in Italy. In this project the main Italian water companies, the University of Genoa and the National Institute of Health in Rome are involved.

Proficiency tests on this issue have recently been carried out, involving the National Institute of Health and major Italian water managing companies

This project is sponsored by Fondazione AMGA.



SMAT, Hera and Iren

signed an agreement for developing a partnership on specific research projects aimed at:

- Fixing priorities for choosing joined research projects of common interest;
- Participating in national and international tenders on research programmes, with special care to those included in the Framework Programme of the European Commission;
- Developing and promoting activities of common interest, thanks to the international networks to which they belong.

Developing a network of laboratories for managing analytical and monitoring issues regarding the environment and possible changes in regulation

The project is focused on emerging critical issues regarding the integrated water cycle. Analytical techniques will be developed and specialist areas will be identified for the three laboratories (HERA-IREN-SMAT). The issue of the Emerging Compounds is a definite priority (Hexavalent Chromium, Emerging Compounds, Endocrine Disrupters, Pesticides, etc.), as confirmed by the

COMMISSION IMPLEMENTING DECISION (EU) 2015/495 of 20 March 2015, establishing a watch list of substances for Union-wide monitoring in the field of water policy pursuant to Directive 2008/105/EC of the European Parliament and of the Council.

COMMISSION IMPLEMENTING DECISION (EU) 2015/495

ANNEX

Watch list of substances for Union-wide monitoring as set out in Article 8b of Directive 2008/105/EC

17-Alpha-ethinylestradiol (EE2)
17-Beta-estradiol (E2), Estrone (E1)
Diclofenac
2,6-Ditert-butyl-4-methylphenol
2-Ethylhexyl 4-methoxycinnamate
Macrolide antibiotics
Methiocarb
Neonicotinoids
Oxadiazon
Tri-allate