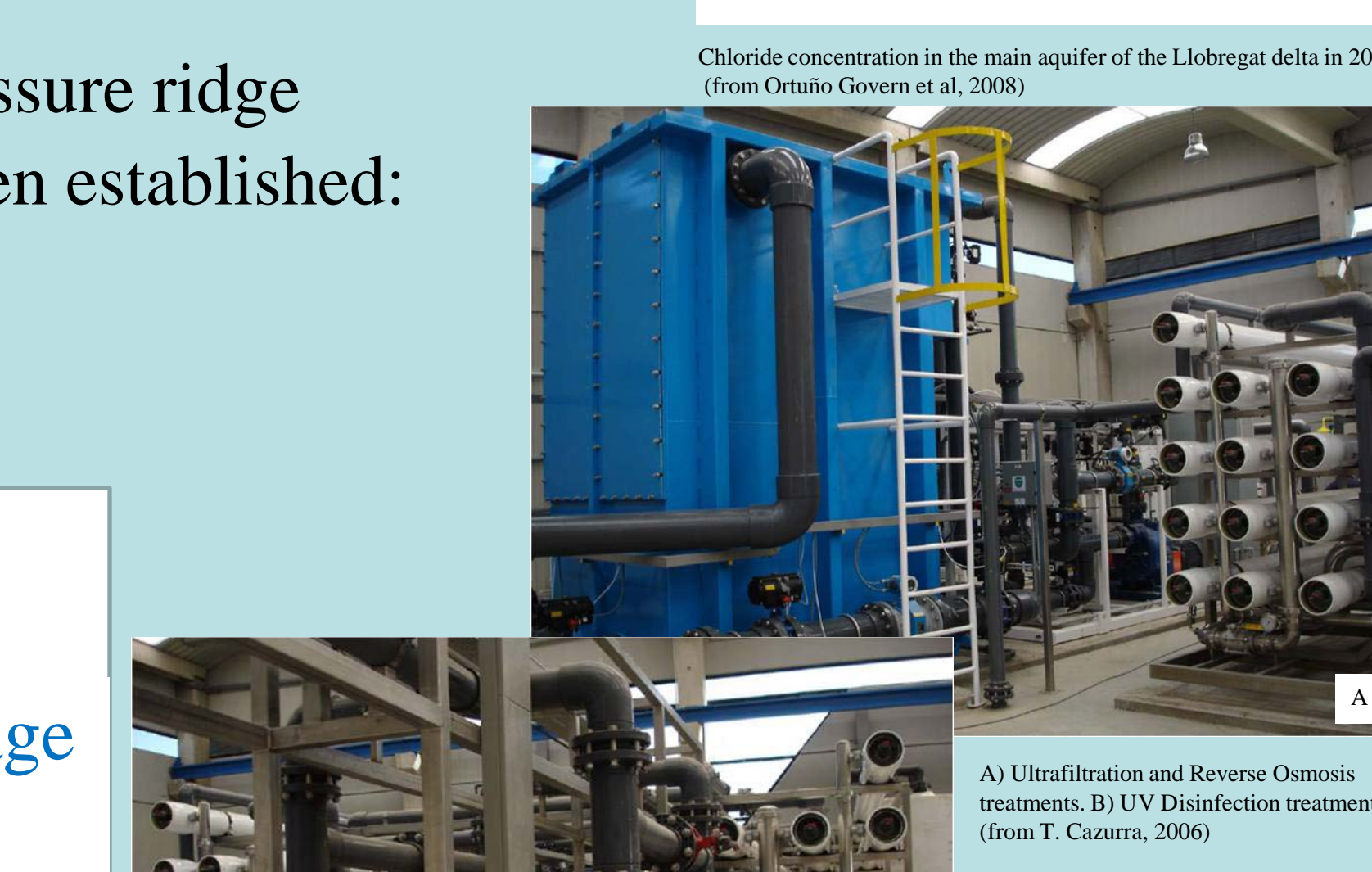
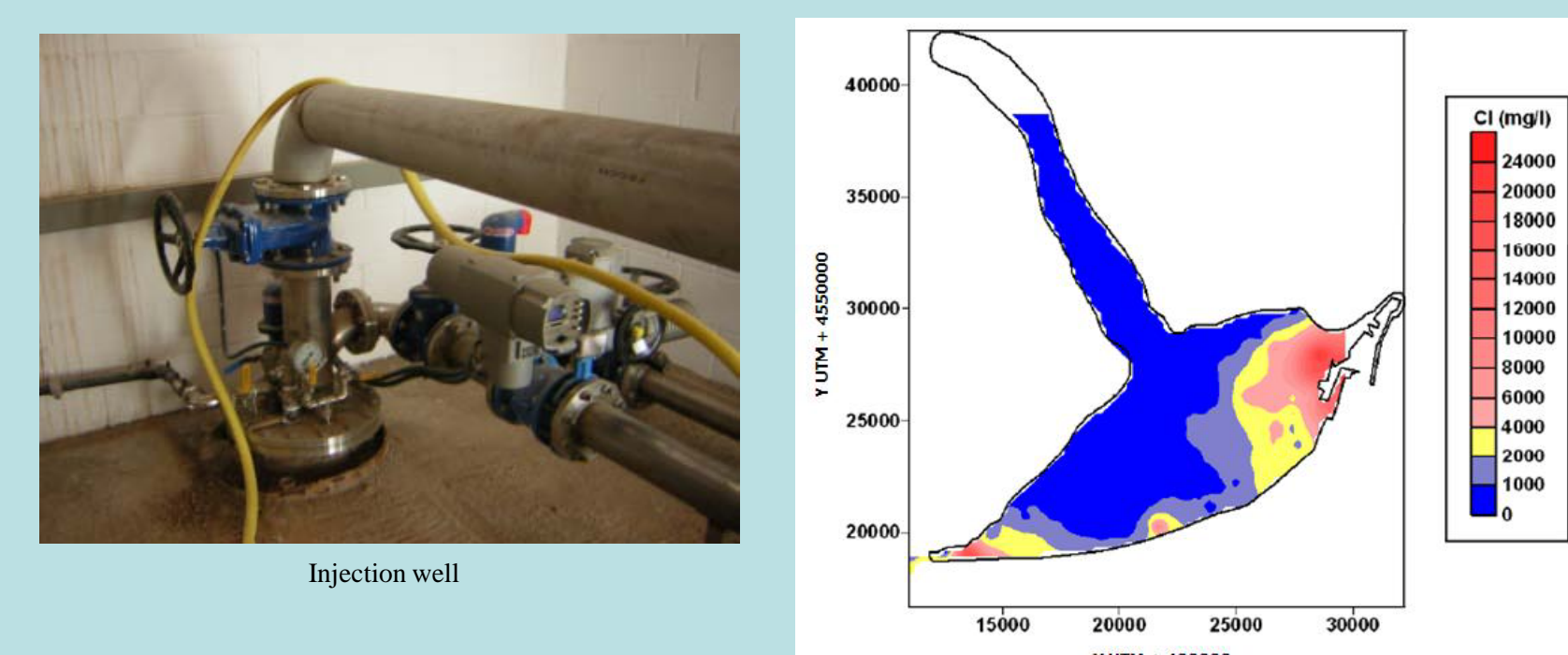
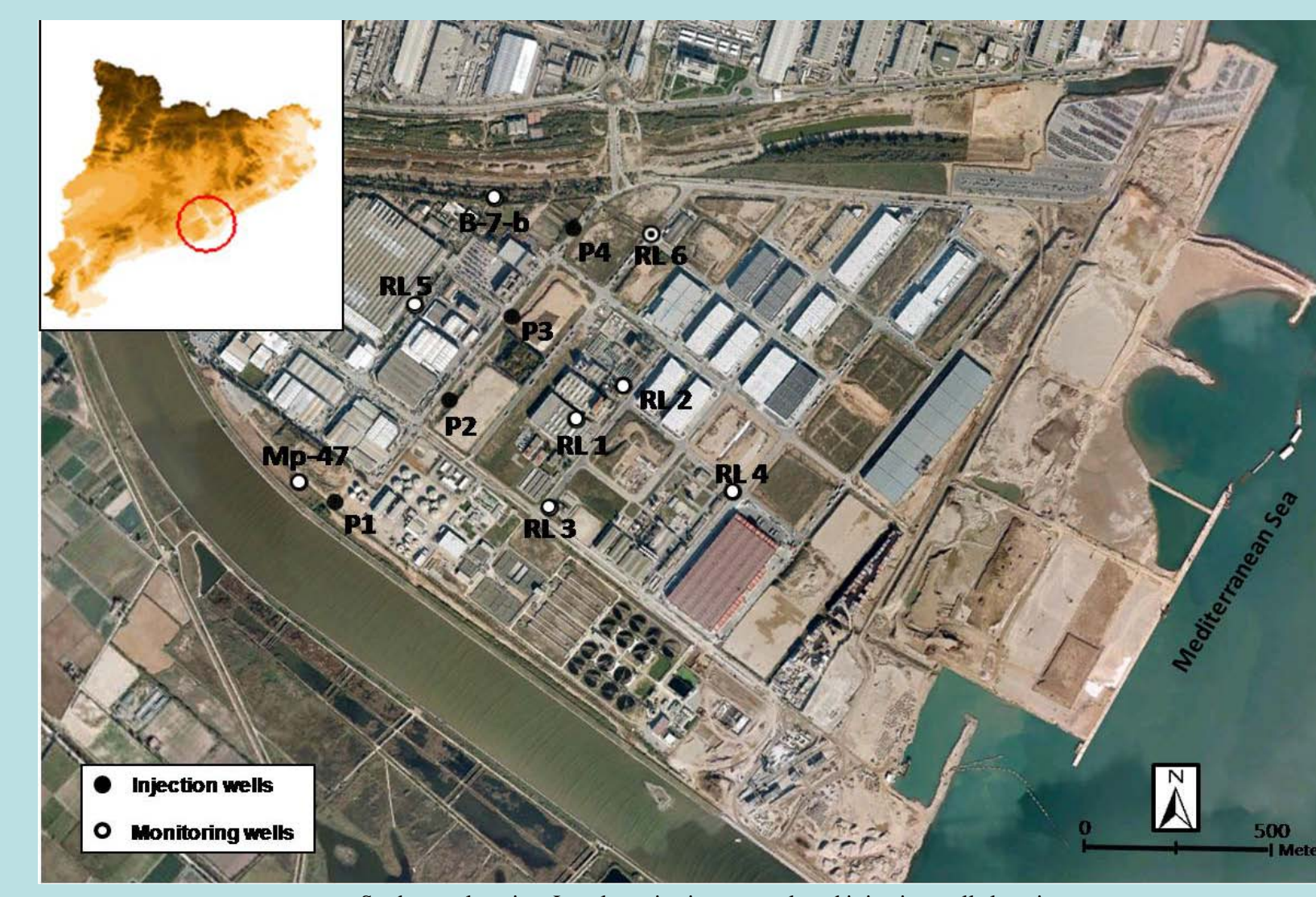


# PRESENCE OF EMERGING CONTAMINANTS, PRIORITY SUBSTANCES AND HEAVY METALS IN TREATED WASTEWATER AND GROUNDWATER IN THE LLOBREGAT DELTA AREA (BARCELONA, SPAIN)

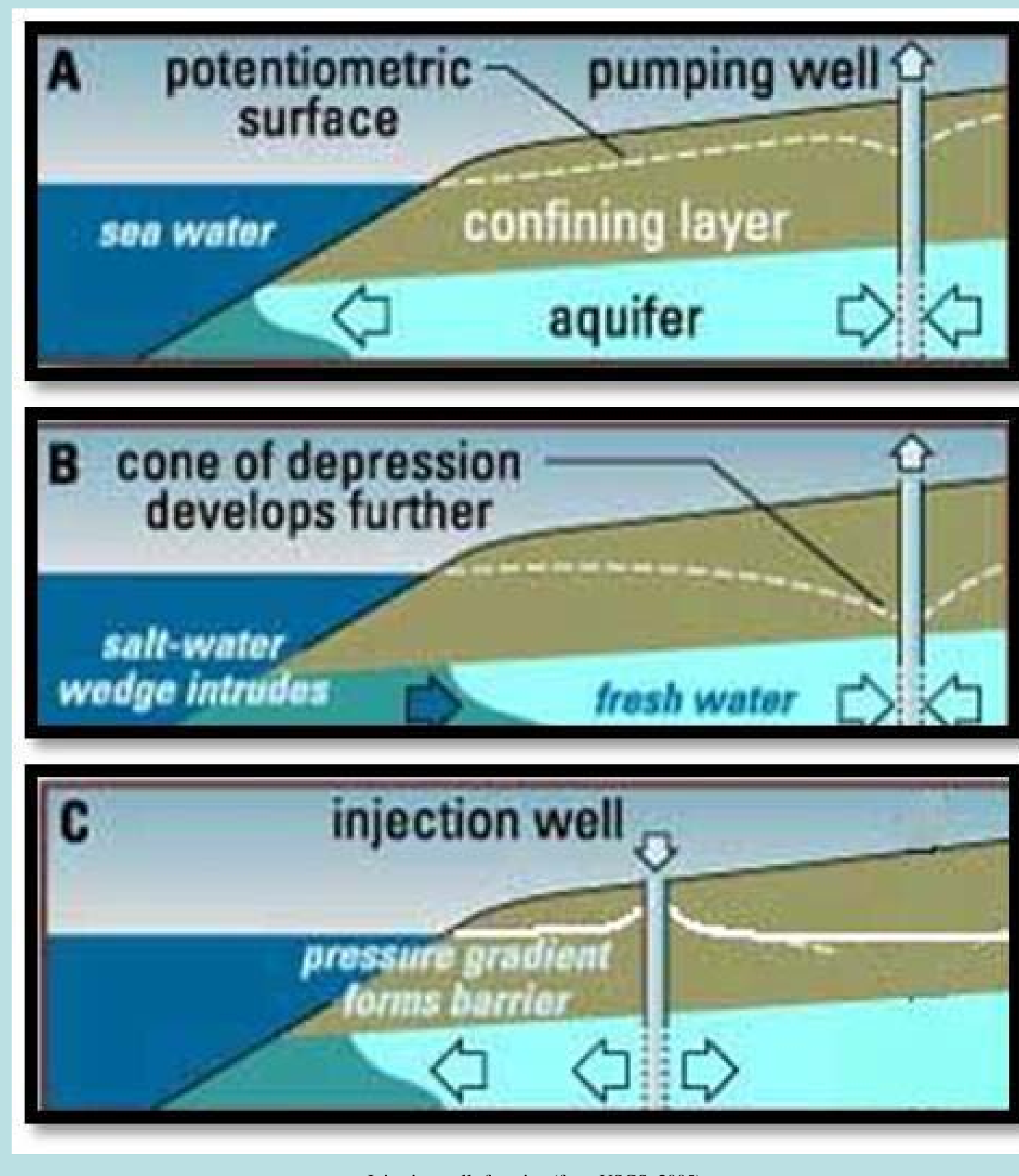
Teijón, Gloria; Tamoh, Karim; Candela, Lucila Candela  
 Dep. of Geotechnical Engineering and Geoscience-UPC. Gran Capitán s.n. 08034 Barcelona (Spain)  
[gloria.teijon@upc.edu](mailto:gloria.teijon@upc.edu), [karim.tamoh@upc.edu](mailto:karim.tamoh@upc.edu), [lucila.candela@upc.edu](mailto:lucila.candela@upc.edu)



Reuse of water originating from sewage treatment plants considers that all possible polluting agents are eliminated through standard treatment. However, not all contaminants are removed through standard treatments. A number of compounds are known to persist through tertiary treatment process in an unaltered form. Between these persistent compounds is the emergent polluting agent group. The occurrence of 170 emerging contaminants, priority substances (2008/105/CE Directive) and heavy metals has been investigated in the Llobregat aquifer. Among micro contaminants selected are 82 pharmaceuticals (antibiotics, lipid regulating agents, analgesic/anti-inflammatory drugs, etc) 18 personal care products (sunscreen agents, preservatives and disinfectants/antiseptics), 4 metals, 44 pesticides, 6 volatile priority pollutants, 16 PAHS and dioxins. Water samples were obtained from municipal wastewater tertiary treatment plant (WWTP) and from water with an additional treatment (WWATP) for the seawater hydraulic barrier injection and from the aquifer receiving recharge.

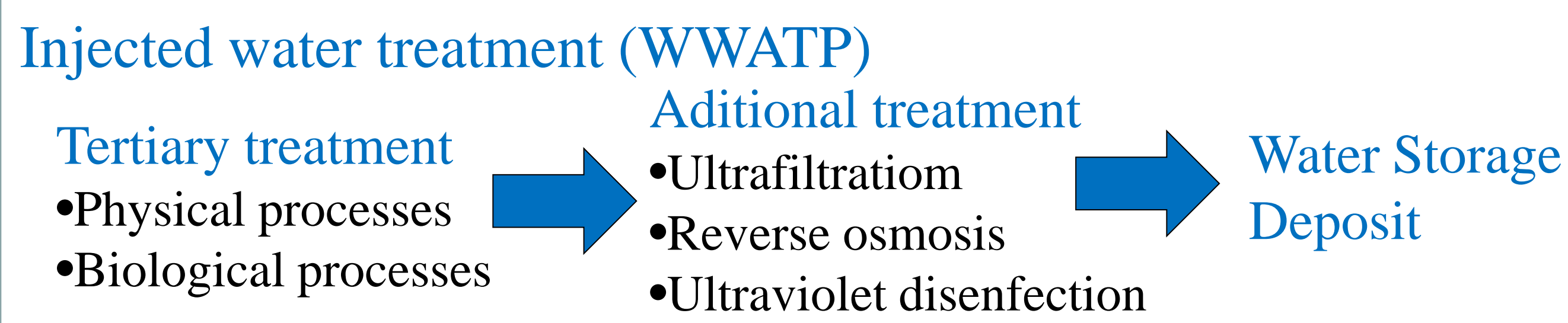
The Llobregat river delta, southwest of Barcelona, is a Quaternary age coastal formation characterised by two aquifers (the upper and lower aquifer). The deep aquifer is the aquifer of the concern due to:

- Main aquifer of the delta: Strategic water resource for the Barcelona Area, under a great exploitation since the 60s
  - ➔ important piezometric level decrease ➔ water intrusion ➔ deterioration in the groundwater quality
- To solve the seawater intrusion problem: the implementation of an hydraulic barrier



**Hydraulic Barrier:** Injecting treated wastewater to conform a pressure ridge along the coast, stopping the seawater from entering the aquifer has been established:

- Four injections wells were constructed for water injection (P1 to P4)
- Water injection started in March 2007
- Daily volume injected : 2500m<sup>3</sup>/day



**Monitoring for water quality**

- Inlet-outlet wastewater treatment plant
- Storage tank (for injection)
- Groundwater (wells located at 1km distance from injection wells)

## Results

**Pharmaceuticals:** The most detected group, in frequency and concentration.

- After tertiary treatment ➔ Concentration still high (>>0.1µg/l)
- After WWATP treatment ➔ Concentrations reduced below 0.1 µg/l. Some of them are totally removed from water
- In groundwater ➔ Presence in the range of ng/l
- Most commonly detected: stimulants, anaesthetics, diuretics, blood lipid regulators, antibiotics and analgesics.
- Some compounds detected in groundwater were not found in injected water

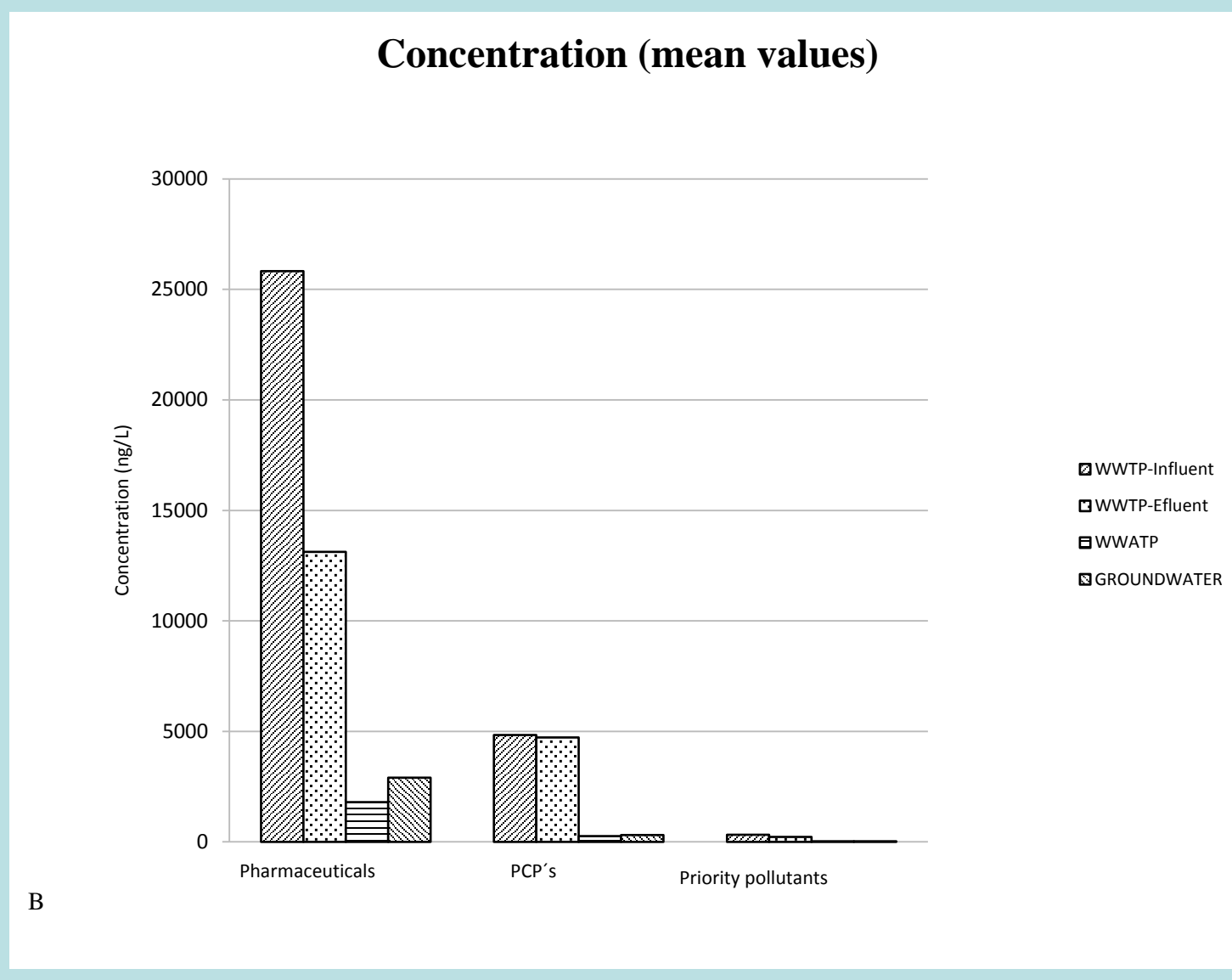
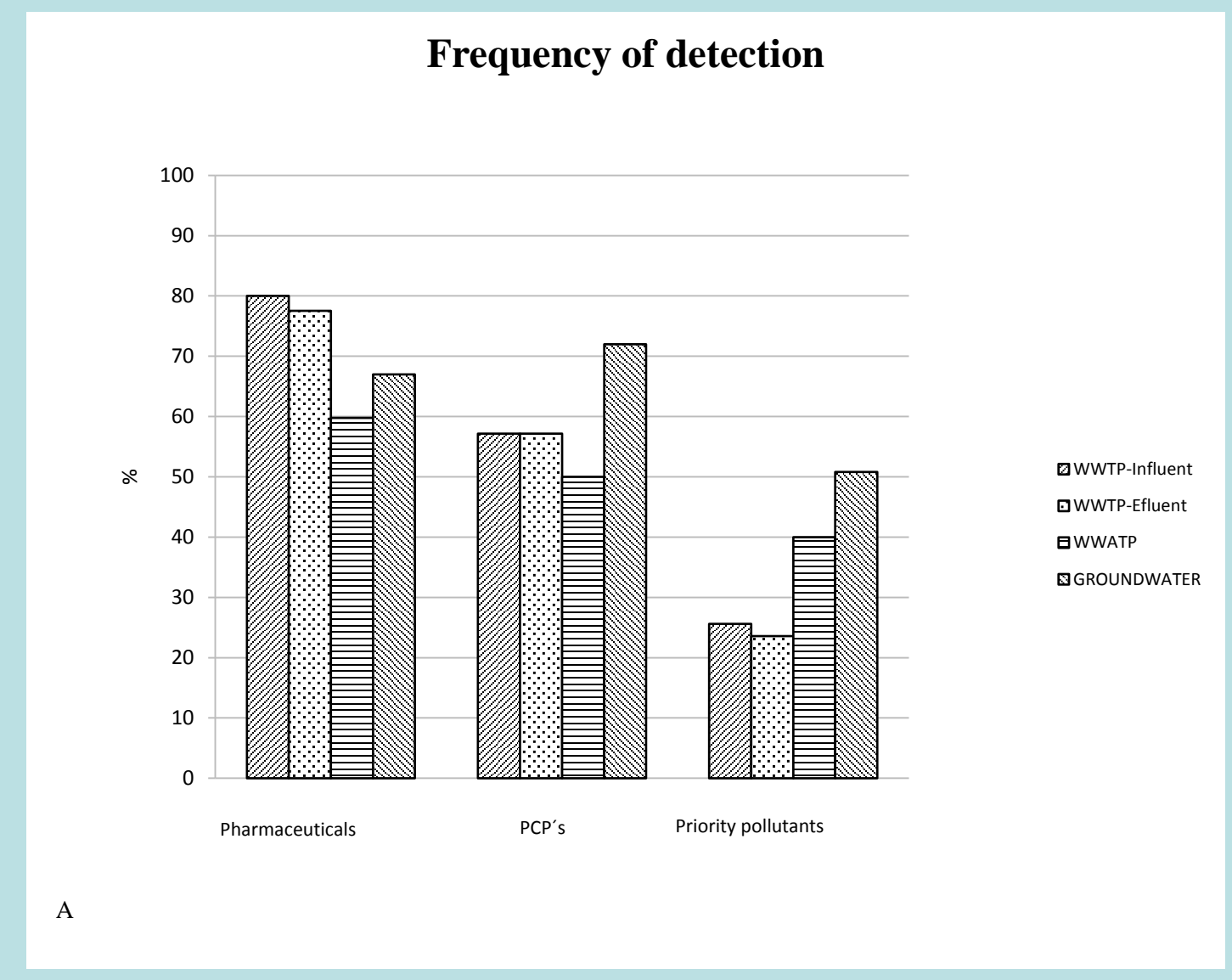
**Personal Care Products:**

- After WWATP, 7 compounds found in groundwater
- Only Galaxolide (fragrance), BHT (antioxidant) and TCPP (flame retardant) detected with concentration > 0.1 µg/l in samples from the aquifer

**Pesticides, other priority contaminants and metals:**

- Diuron (herbicide), α-HCH, β-HCH, δ-HCH, Simazine and Hexachlorobenzene (fungicides)
  - ➔ the only pesticides found in all types of sampled waters (compounds included in 2008/105/CE Directive))
- Ni and Pb ➔ found in all types of water.
- Only Cd and Ni ➔ above the maximum allowable concentration according to the directive

| Pharmaceuticals                                       | Personal care products          | PAHs and dioxins                     | Pesticide                             | Volatile priority pollutants    | Metals |
|---|---------------------------------|--------------------------------------|---------------------------------------|---------------------------------|--------|
| 4-amino-antipyrine (4-AA)                             | 2,7,8-dichloro-dibenzo-p-dioxin | 2,3,7,8-tetrachloro-dibenzo-p-dioxin | 4,4'-DDE                              | 1,2,3-trichlorobenzene          | Cd     |
| 4-dimethylaminoantipyrine (4-DAA)                     | camphor                         | 3-(4-methylbenzylidene)              | 4,4'-DDT                              | 1,2,4-trichlorobenzene          | Hg     |
| Acetaminophen   | Benzophenone-3                  | Acenafeno                            | Alachlor                              | 1,3,5-trichlorobenzene          | Ni     |
| Amiripyline   | BHT                             | Acenaphthylene                       | Aldrin                                | Hepta-brominated diphenyl ether | Pb     |
| Amoxicillin   | Biphenylol                      | Benzo (a) anthracene                 | Alpha-endosulfan                      | Tetra-brominated diphenyl ether |        |
| Antipyrine  | Celestolide                     | Benzo (a) fluoranthene               | Ametryn                               |                                 |        |
| Atenolol  | Chlorophene                     | Benzo (a) pyrene                     | Atrazin desethyl                      |                                 |        |
| Azithromycin  | Ethylhexyl methoxycinnamate     | Benzo (b) fluoranthene               | Atrazine                              |                                 |        |
| Benazofibrate   | Galaxolide                      | Benzo (k) fluoranthene               | Beta-endosulfan                       |                                 |        |
| Caffeine  | Musk ketone                     | Chrysene                             | Beta-hexachlorocyclohexane            |                                 |        |
| Caffeine C13  | Musk xylene                     | Octocrylene                          | Chlorfeninfos A                       |                                 |        |
| Carb.Episide  | Octocrylene                     | Dibenzof(a,h)anthracene              | Chlorfeninfos B                       |                                 |        |
| Carbamazepine   | Octyl-triazone                  | Fluoranthene                         | Chloropyrifos ethyl                   |                                 |        |
| Cefotaxime  | Phantolide                      | Fluorene                             | Chlorotoluron                         |                                 |        |
| Ciprofloxacin   | TCPP                            | Indene(1,2,3-cd)pyrene               | Chlorpyrifos-Methyl                   |                                 |        |
| Citalopram  | Tonalide                        | Pyrene                               | Chrysene                              |                                 |        |
| Clarithromycin  | Trasolide                       |                                      | Delta-hexachlorobenzene               |                                 |        |
| Clotifric acid  | Triclosan                       |                                      | Deltamethrin                          |                                 |        |
| Chomipramine  |                                 |                                      | Diazinon                              |                                 |        |
| Clotrimazole  |                                 |                                      | Dieldrin                              |                                 |        |
| Codeine   |                                 |                                      | Diuron                                |                                 |        |
| Cotinine  |                                 |                                      | Endosulfan sulphate                   |                                 |        |
| Cyclophosphamido                                      |                                 |                                      | Endrin                                |                                 |        |
| Diazinon  |                                 |                                      | Ethion                                |                                 |        |
| Diazepam  |                                 |                                      | Gamma-hexachlorocyclohexane (lindane) |                                 |        |
| Diclofenac  |                                 |                                      | Heptachlor                            |                                 |        |
| Erythromycin  |                                 |                                      | Hexachloro 1,3-butadiene              |                                 |        |
| Famotidine  |                                 |                                      | Hexachlorobenzene                     |                                 |        |
| Fenofibrate   |                                 |                                      | Iprodion                              |                                 |        |
| Fenofibrilic Acid                                     |                                 |                                      | Isofludrin                            |                                 |        |
| Fenoprofen  |                                 |                                      | Isoproturon                           |                                 |        |
| Fluoxechine   |                                 |                                      | Metoxychlor                           |                                 |        |
| Furosemide  |                                 |                                      | Naftalene                             |                                 |        |
| Gemfibrozil   |                                 |                                      | Parathion ethyl                       |                                 |        |
| Hydrochlorothiazide                                   |                                 |                                      | Parathion methyl                      |                                 |        |
| Ibuprofen   |                                 |                                      | Pentachlorobenzene                    |                                 |        |
| Ioxofamide  |                                 |                                      | Phenanthrene                          |                                 |        |
| Indometacin   |                                 |                                      | Procymidone                           |                                 |        |
| Iopamidol   |                                 |                                      | Propazine                             |                                 |        |
| Iopromide   |                                 |                                      | Propranolol hydrochloride             |                                 |        |
| Ketoprofen  |                                 |                                      | Propylphenazone                       |                                 |        |
| Ketorolac   |                                 |                                      | Ranitidine                            |                                 |        |
| Lansoprazole  |                                 |                                      | Salbutamol                            |                                 |        |
| Lincosamin  |                                 |                                      | Salicylic Acid                        |                                 |        |
| Loratadine  |                                 |                                      | Simvastatin                           |                                 |        |
| Mefenamic Acid  |                                 |                                      | Sotalol                               |                                 |        |
| Mepivacaine   |                                 |                                      | Sulfadiazine                          |                                 |        |
| Methylprednisolone 6-alpha sodium succinate (Urbason) |                                 |                                      | Sulfamethazine                        |                                 |        |
| Metoprolol  |                                 |                                      | Sulfamethoxazole                      |                                 |        |
| Metronidazole   |                                 |                                      | Sulfapyridine                         |                                 |        |
| Mevastatin  |                                 |                                      | Sulfathiazole                         |                                 |        |
| N-acetyl-4-amino-antipyrine (4-AAA)                   |                                 |                                      | Tamoxifen                             |                                 |        |
| Nadolol   |                                 |                                      | Terbutaline                           |                                 |        |
| Naproxen  |                                 |                                      | Tetracycline                          |                                 |        |
| N-formyl-4-amino-antipyrine (4-FAA)                   |                                 |                                      | Trimethoprim                          |                                 |        |
| Nicotine  |                                 |                                      | Velafaxime                            |                                 |        |
| Norfloxacin   |                                 |                                      |                                       |                                 |        |
| Ofloxacin   |                                 |                                      |                                       |                                 |        |
| Omeprazole  |                                 |                                      |                                       |                                 |        |
| Paraxanthine  |                                 |                                      |                                       |                                 |        |
| Paroxethine   |                                 |                                      |                                       |                                 |        |
| Phenacetin  |                                 |                                      |                                       |                                 |        |
| Pravastatin   |                                 |                                      |                                       |                                 |        |
| Primidone   |                                 |                                      |                                       |                                 |        |
| Propranolol hydrochloride                             |                                 |                                      |                                       |                                 |        |
| Propylphenazone                                       |                                 |                                      |                                       |                                 |        |
| Ranitidine  |                                 |                                      |                                       |                                 |        |
| Salbutamol  |                                 |                                      |                                       |                                 |        |
| Salicylic Acid  |                                 |                                      |                                       |                                 |        |
| Simvastatin   |                                 |                                      |                                       |                                 |        |
| Sotalol   |                                 |                                      |                                       |                                 |        |
| Sulfadiazine  |                                 |                                      |                                       |                                 |        |
| Sulfamethazine  |                                 |                                      |                                       |                                 |        |
| Sulfamethoxazole                                      |                                 |                                      |                                       |                                 |        |
| Sulfapyridine   |                                 |                                      |                                       |                                 |        |
| Sulfathiazole   |                                 |                                      |                                       |                                 |        |
| Tamoxifen   |                                 |                                      |                                       |                                 |        |
| Terbutaline   |                                 |                                      |                                       |                                 |        |
| Tetracycline  |                                 |                                      |                                       |                                 |        |
| Trimethoprim  |                                 |                                      |                                       |                                 |        |
| Velafaxime  |                                 |                                      |                                       |                                 |        |



- The study revealed that a small numbers of compounds were efficiently removed after tertiary treatment.

- After the WWATP treatment the majority of analites are removed from tertiary treated wastewater of their concentration is reduced significantly

- 26 contaminants detected in groundwater are not detected in the injected water, it seems probably that their presence is related to the natural aquifer recharge.

- Injected water contributes to the improvement of groundwater quality

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