Introduction to Sensory Analysis of Water

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Training School “AOPs for water T&O”
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Is water tasteless and odorless ?

Water

From Wikipedia, the free encyclopedia

"H2O" redirects here. For other uses, see H_2O (disambiguation) and Water (disambiguation).

Water (chemical formula **H_2O**) is an inorganic, transparent, tasteless, odorless, and nearly colorless chemical substance, which is the main constituent of Earth's hydrosphere and the fluids of all known living organisms (in which it acts as a solvent[1]). It is vital

WIKIPEDIA
The Free Encyclopedia

OxfordLanguages

Dictionary

Definitions from Oxford Languages · Learn more

water

water

/ˈwɔːtə/

See definitions in:

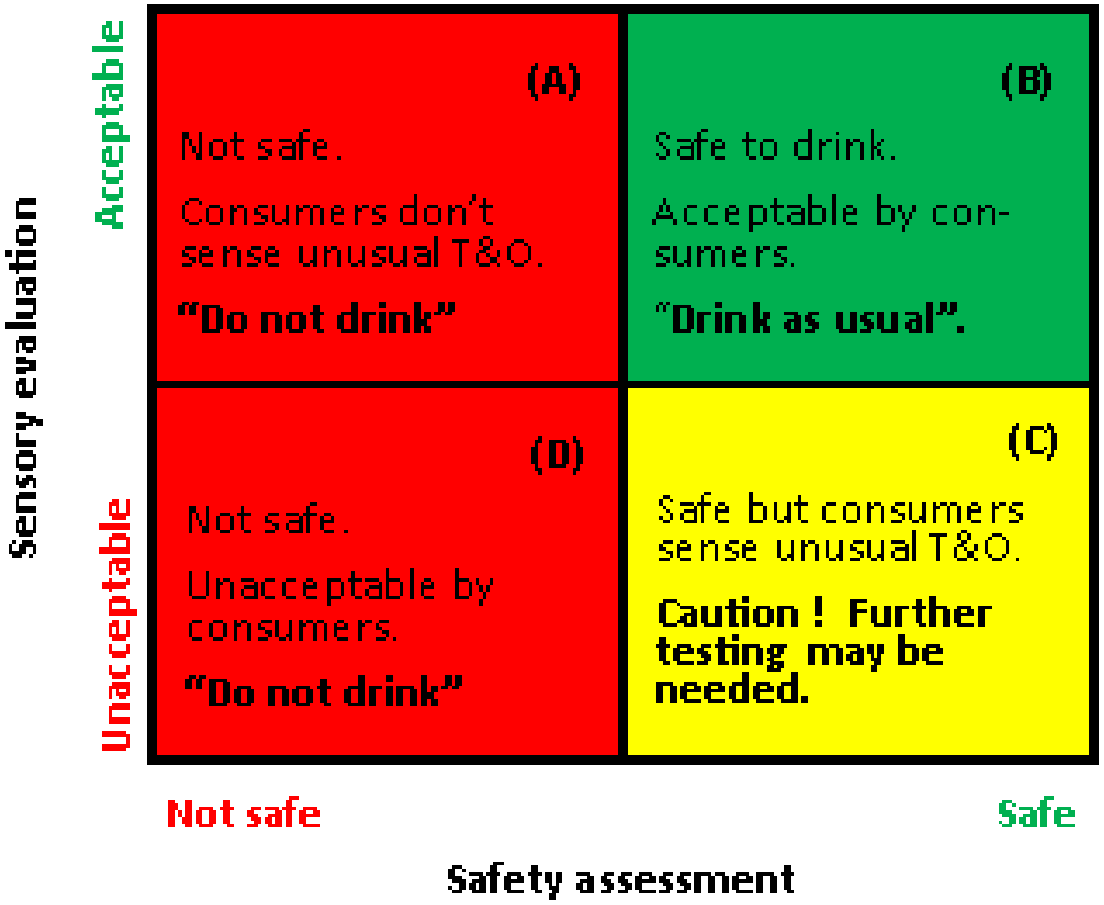
All | Chemistry | Astrology | Medicine | Jewellery | Finance | Agriculture | Geography

noun

1. a colourless, transparent, odourless liquid that forms the seas, lakes, rivers, and rain and is the basis of the fluids of living organisms.
   "sodium chloride dissolves in water"

Similar: aqua | H_2O | Adam's ale

Safety and sensory assessment of drinking water



Akcaalan et al. 2022, WaterTOP Perspective on water T&O, submitted to CEJA.

Drinking water fact:
T&O is the most frequent source of consumer complaints

A plethora of T&O can occur at various stages of drinking water production

Lakes (e.g. plankton metabolites and degradation products)

Geosmin, MIB, α- and β-ionones, β-cyclocitral, pyrazines, sulfurous compounds aldehydes, amines

(earthy, musty, fishy, swampy etc odors)

Water treatment

Chlorinated compounds, chloramines, degradation products etc

Distribution network

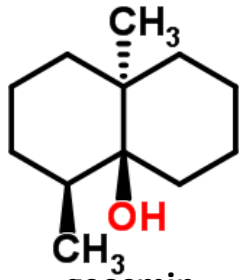
Trichloroanisole, compounds migrating from contact with materials

Household network

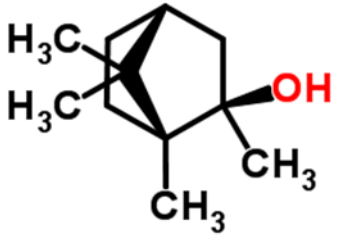
Plasticizers, fuels (BTEX), industrial solvents etc etc

Common sources of water T&O

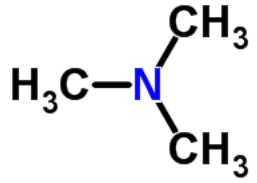
Surface Water Reservoirs
Algal metabolites



geosmin
(earthy)



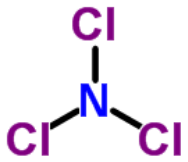
2-methylisoborneol
(musty)



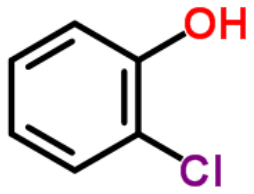
trimethylamine
(fishy)

Dimethyl trisulfide
(septic)

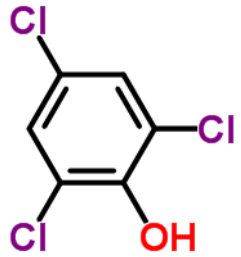
Water treatment
Chlorination products



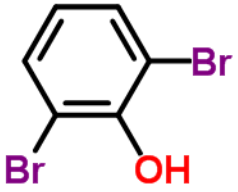
Trichloramine
(swimming pool)



2-chlorophenol
(chemical)

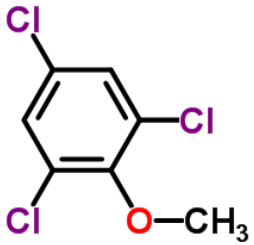


2,4,6-trichlorophenol
(medicinal)

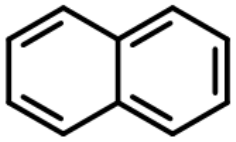


2,6-dibromophenol
(medicinal)

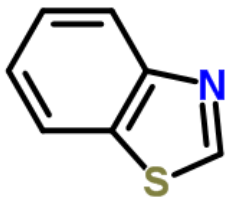
Distribution network
biofilm activity, materials in contact



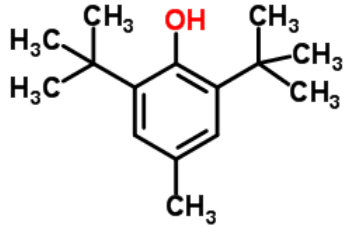
2,4,6-trichloroanisole
(musty)



naphthalene
(mothballs)



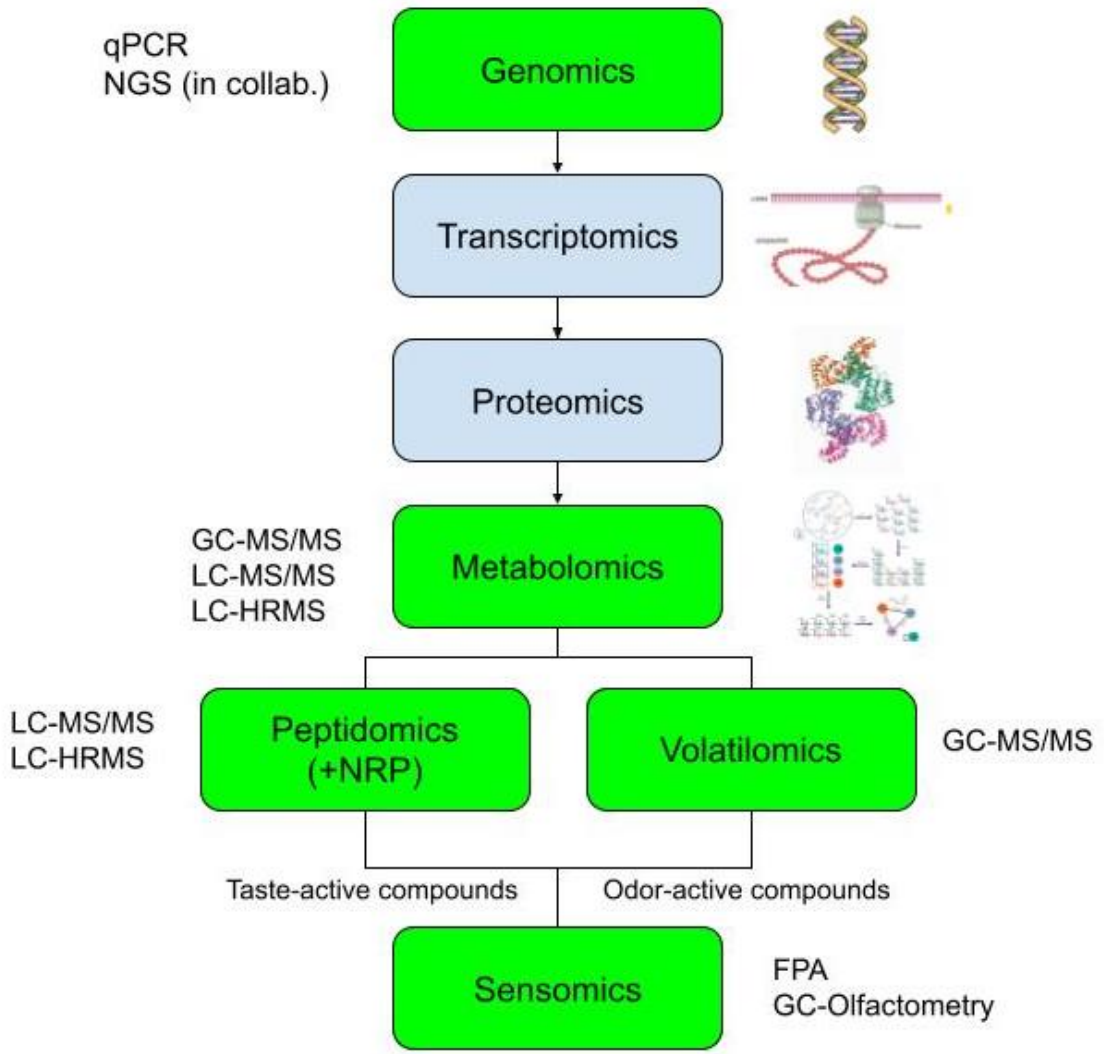
benzothiazole
(plastic)



BHT
(plastic)

Water T&O at LOM/EYDAP and LEAD/Demokritos

Algal metabolomics



Kaloudis 2021, Toxic Cyanobacteria in Water 2nd Ed., WHO
Granvogl & Schieberle 2022, Compr. Anal. Chem

Anthropogenic T&O

- Industrial pollution
- Water Treatment
- Materials in contact with water
- Transformation products

WaterTOP
COST ACTION CA18225
www.watertopnet.eu

cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

LABORATORY OF ORGANIC MICROPOLLUTANTS

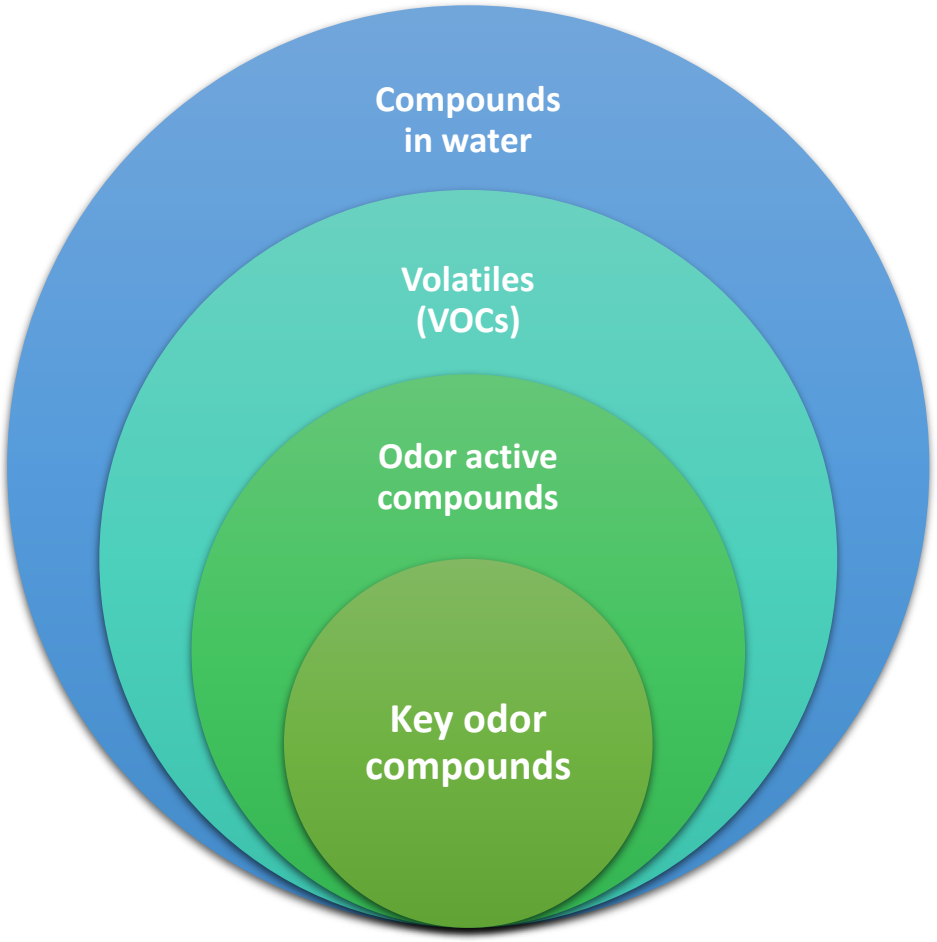
EYDAP

Institute Nanoscience Nanotechnology
Ινστιτούτο Νανοεπιστήμης Νανοτεχνολογίας

LEAD
LABORATORY OF ENVIRONMENTAL ANALYSIS
NCSR DEMOKRITOS

Which compounds contribute to water odor ?

Volatiles vs odor active compounds

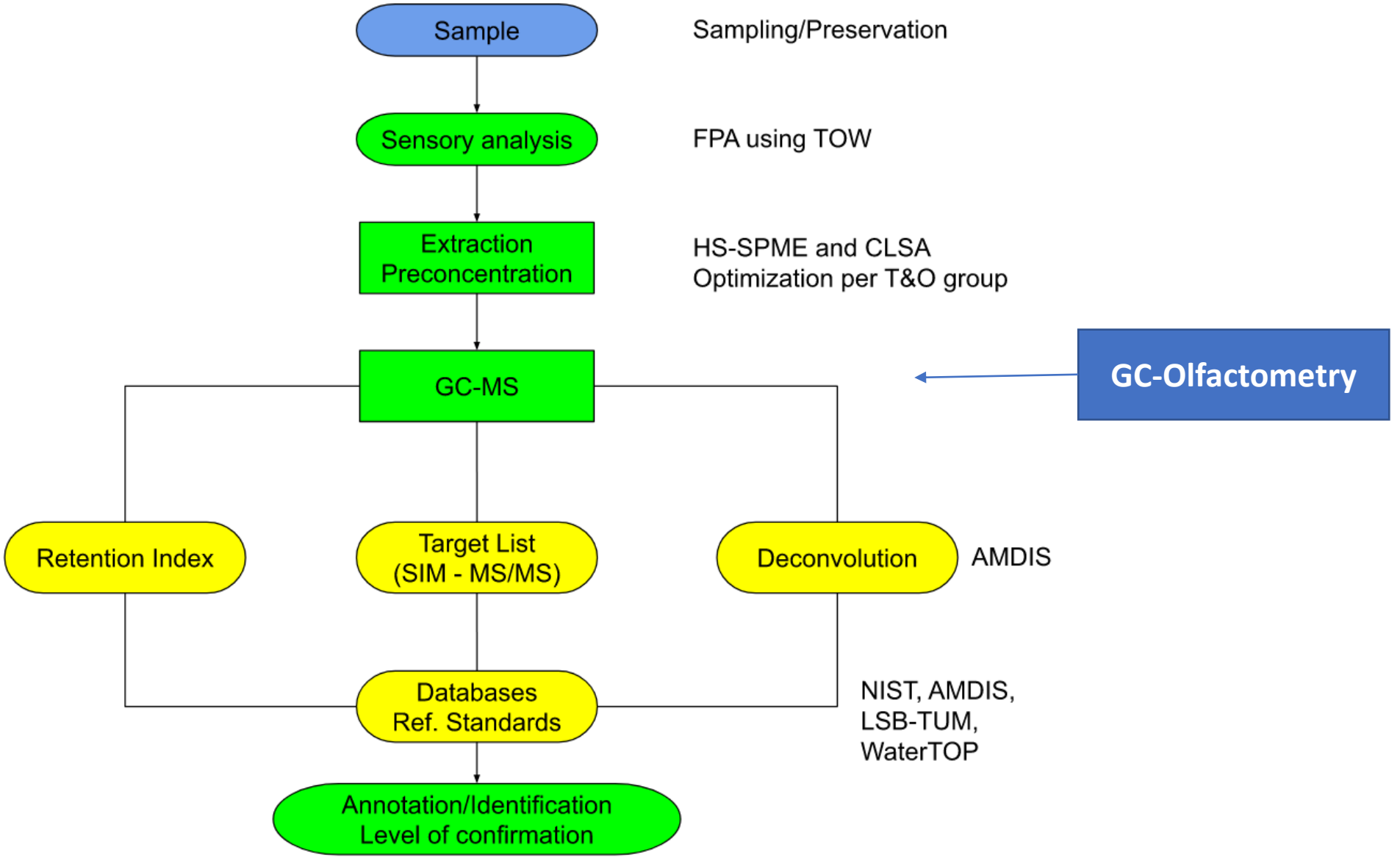


Examples of Threshold Odor Concentrations (TOC)

Compound	Mean Odor Threshold in water (µg/L)	Descriptor
geosmin	0.004	earthy
2-MIB	0.015	musty
2-Isobutyl-3-methoxypyrazine	0.0001	stale, musty
2,4,6 TCA	0.0009	musty, earthy
naphthalene	6	mothballs
chloroform	30000	chemical, antiseptic
b-cyclocitral	19	tobacco, woody
dimethyl trisulfide	0.010	septic
b-ionone	0.007	violets

Young et al. (1996), Water Research, 30(2),331-340
Cotsaris et al. (1995), WST, 31(11), 251-258.

Basic workflow for diagnosis of water odor episodes



LABORATORY OF ORGANIC MICROPOLLUTANTS

EYDAP

Cyanobacteria – algae volatilome (VOCs – odor active)

- Odorous metabolites (geosmin, MIB, ionones, b-cyclocitral etc).
- Non-odorous volatile metabolites (e.g. hydrocarbons).
- Cell degradation products (aldehydes, sulfurous compounds, amines etc).
- Transformation products (bacterial, chemical, biochemical transformation).

Ecological role:

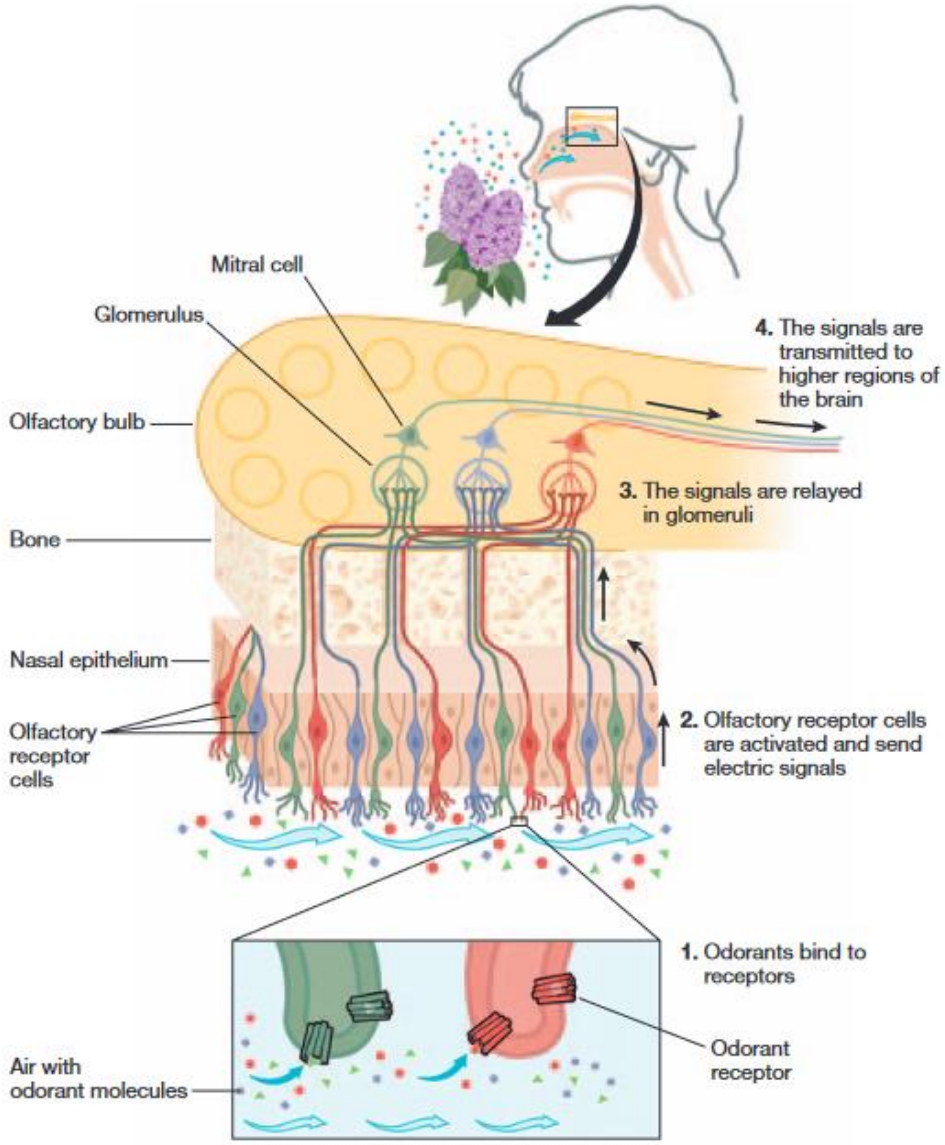
- Signaling compounds?
- Allelopathic interactions?
- Pheromones?

E.g. Role of b-cyclocitral in cell lysis: Ozaki et al. (2008), Chemosphere, 71, 1531-1538
Role of b-cyclocitral in "black blooms": Yu et al. (2016), Ecol. Eng. 87, 246-253.

Hazards and benefits ?

The human olfactory system

- Chemoreception (chemosensor)
- Molecules are sensed by **olfactory receptors** in the olfactory epithelium.
- About 400 olfactory receptors.
- Response according to chemical structure of the odour compound.
- Signals processed and transmitted to brain to give the overall sense of the smell.
- **Very high sensitivity.**
- Discrimination power.
- Triggers deeply hidden memories.
- The oldest of all senses.



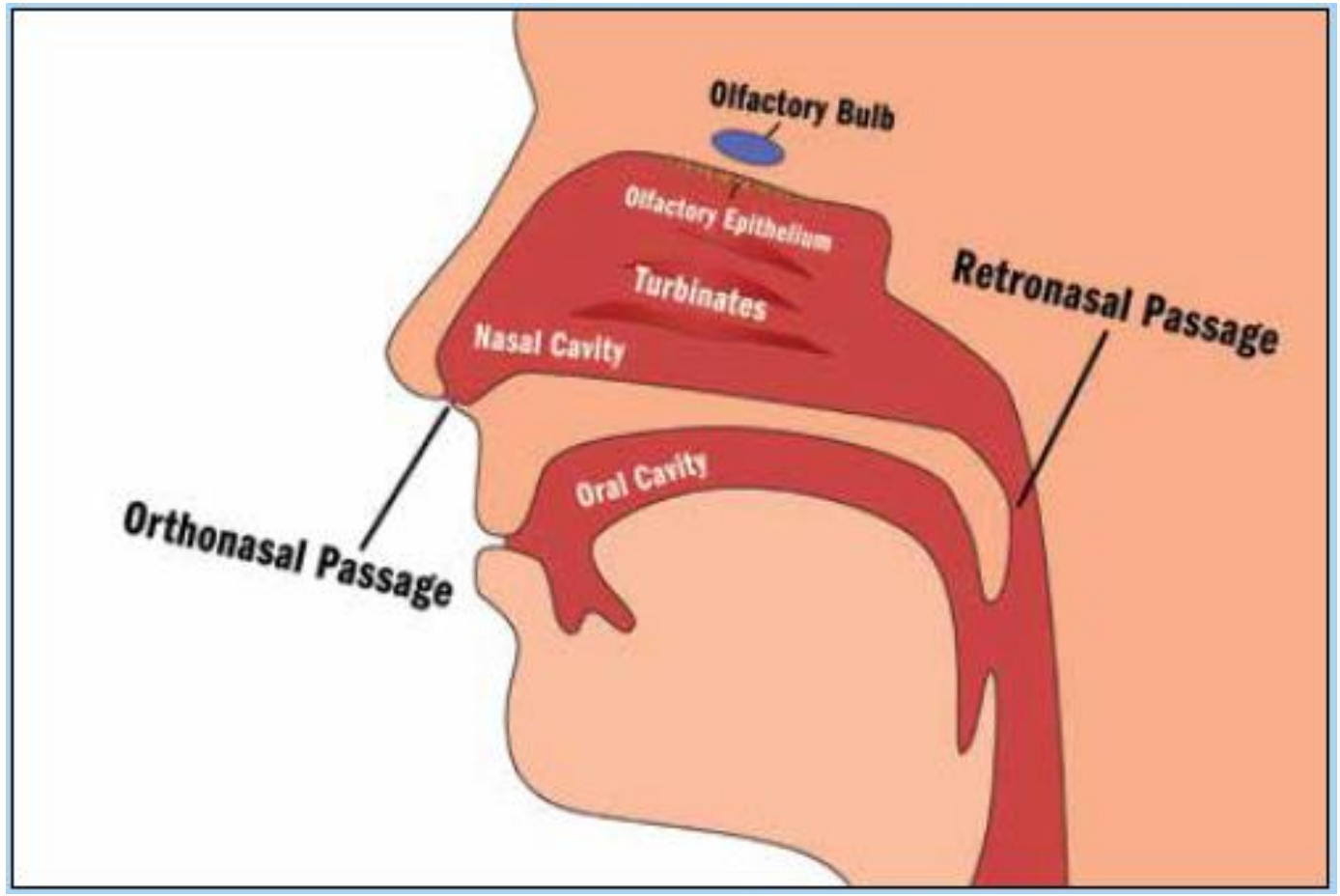
Rinaldi, 2007, EMBO reports, *https://doi.org/10.1038%2Fsj.embor.7401029*

Humans Can Discriminate More than 1 Trillion Olfactory Stimuli

C. BUSHDID, M. O. MAGNASCO, L. B. VOSSHALL, AND , A. KELLER Authors Info & Affiliations

SCIENCE · 21 Mar 2014 · Vol 343, Issue 6177 · pp. 1370-1372 · DOI: 10.1126/science.1249168

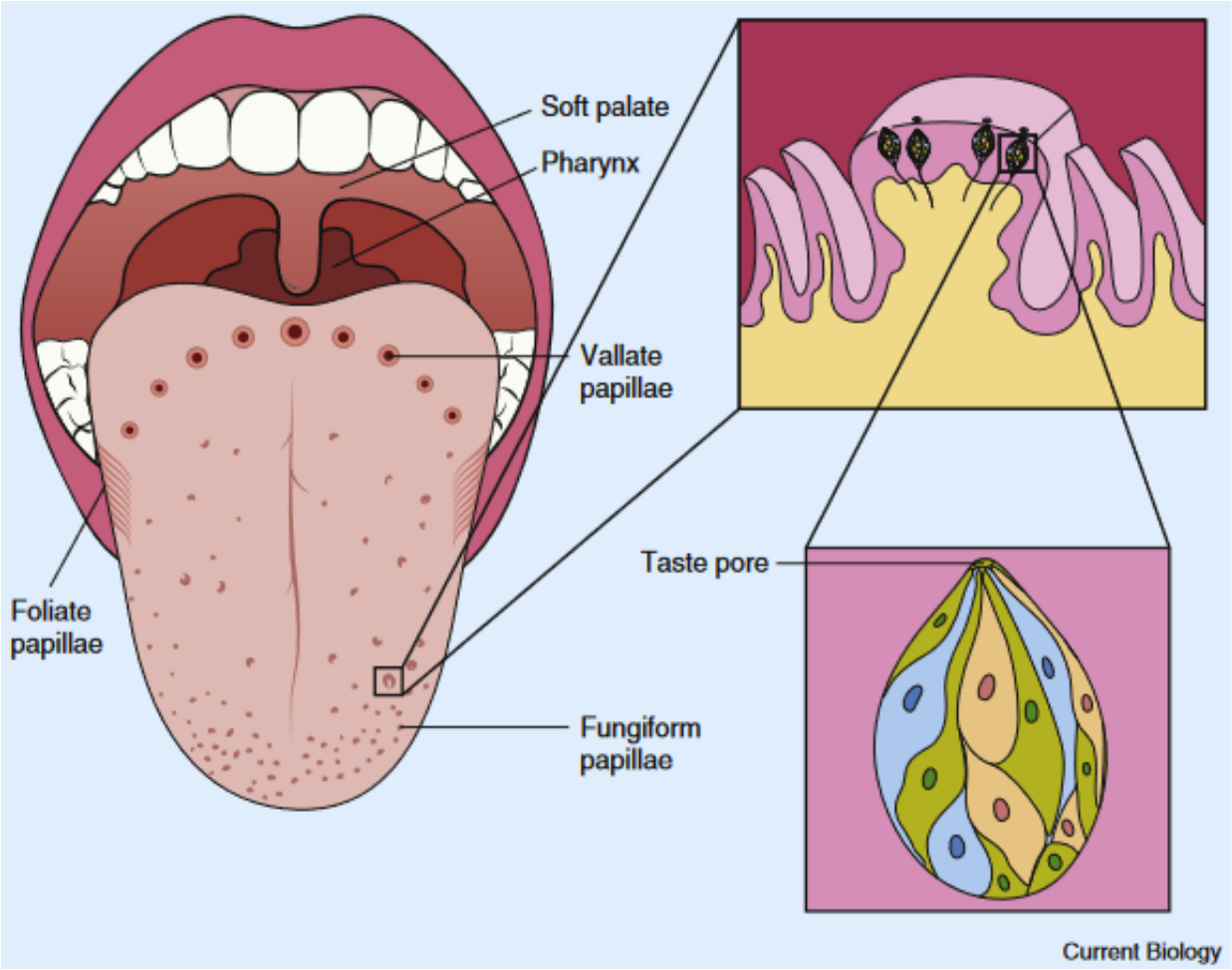
Orthonasal vs Retronasal olfaction



Burlingame & Dietrich, Opflow, 2016

- **Flavor is the combination of taste, odor and mouthfeel.**
  - **Retronasal pathway may be more sensitive (why?).**

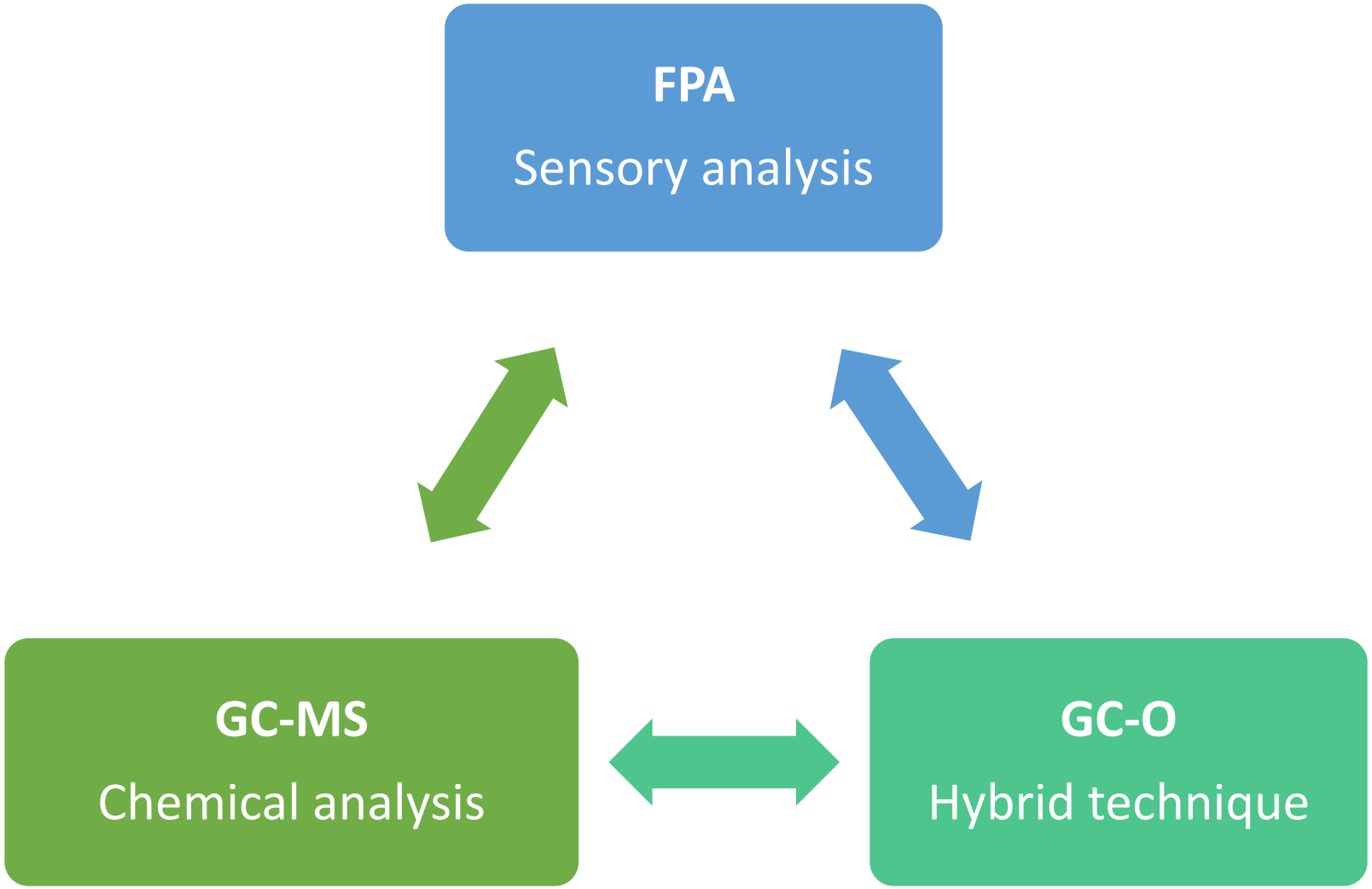
Gustation (sense of taste)



Breslin 2013, Curr. Biol.
https://doi.org/10.1016/j.cub.2013.04.010

- Chemoreception.
- Sensing of chemical compounds at gustatory receptors (tongue).
- **5 basic tastes:**
  - **Sweet**
  - **Sour**
  - **Salty**
  - **Bitter**
  - **Umami**
- Other sensations:
- Hotness
- Coolness
- Temperature
- ….

The role of sensory analysis in diagnosis of water T&O episodes



The role of sensory analysis in drinking water compliance

23.12.2020 EN Official Journal of the European Union L 435/1

I

(Legislative acts)

DIRECTIVES

DIRECTIVE (EU) 2020/2184 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 16 December 2020
on the quality of water intended for human consumption
(recast)

Part C: **Indicator parameters**

Taste	Acceptable to consumers and no abnormal change
Odour	Acceptable to consumers and no abnormal change

- No method specified.
- No units of measurement specified.
- No definition of “taste” & “odor”.
- No definition of consumer acceptability.
- No definition of “abnormal change”.

Intended use of sensory methods

Diagnosis of T&O incidents

Descriptive methods
Flavor Profile Analysis (FPA)
Trained expert panels

GC-Olfactometry

followed by
Chemical analysis (GC-MS)

Assessment of consumers' acceptance

Hedonic methods
5,-7 or 9 point scales to rate the overall liking of water.

Consumer complaints
Monitoring and assessment

Consumer-based studies
Check-All-That-Apply
Check-If-Appy

Threshold methods
TON/TFN

Detect sensory changes

Discrimination methods
Triangle tests
2 out of 5 tests
Ranking tests

Akcaalan et al. 2022, WaterTOP Perspective on water T&O, submitted to CEJA.

Taste and odor threshold concentrations in water

Things to consider:

- Selected/evaluated panelists.
- Panel sizes 6-10 (this study).
- Physical condition of panelists.
- Temperature of water.
- Serial dilutions of T&O compounds.
- TCs are reported as geometric means.
- Large variation, uncertainty.
- Hyper-sensitive individual panelists ?

Table 4. Results of odour threshold concentrations (40°C)

Chemical	Panel size	Geometric mean odour threshold concentration ($\mu g\ l^{-1}$)		Lowest concentration at which an odour was detected ($\mu g\ l^{-1}$)	
Phenolic and anisole compounds					
4-Chloroanisole	8	20	(8)	<2.0	(1)
4-Chloro-2-methylphenol	7	200	(6)	62	(1)
4-Chloro-3-methylphenol	9	5.0	(8)	2.5	(3)
2-Chloro-4-methylphenol	9	0.30	(7)	0.15	(4)
2-Chlorophenol	8	0.36	(6)	0.088	(2)
4-Chlorophenol	9	20	(8)	10	(3)
2,4-Dichloroanisole	9	0.5	(9)	0.21	(3)
2,4-Dichlorophenol	8	29	(4)	5.4	(1)
2,6-Dichlorophenol	8	22	(8)	5.9	(3)
Pentachlorophenol	9	23	(3)	9.3	(1)
Phenol	9	31	(7)	9.5	(2)
2,4,6-Trichloroanisole	6	0.0009	(6)	0.00008	(1)
2,4,5-Trichlorophenol	10	350	(9)	63	(1)
2,4,6-Trichlorophenol	8	—		380	(1)
Naturally occurring organic compounds					
Geosmin	10	0.0038	(10)	0.0013	(4)
2-Isobutyl-3-methoxypyrazine	8	0.001	(8)	<0.00005	(1)
2-Isopropyl-3-methoxypyrazine	6	0.0002	(6)	<0.00003	(2)
2-Methyl-isoborneol	10	0.015	(10)	0.0063	(2)

Notes: N.D.—not determined.
< —Still detected by some of the panel at the lowest test concentration.
> —Not detected by any of the panel at the highest test concentration.
Number of panellists detecting an odour is in brackets

Young et al. (1996), Water Research https://doi.org/10.1016/0043-1354(95)00173-5

In summary

- Sensory quality of water is an important aspect of its overall quality/safety assessment.
- Numerous chemicals (natural or anthropogenic) can give unpleasant taste & odor in water.
- When we drink water we sense its “flavor” which is the combination of its taste & odor.
- Sensory testing for compliance of drinking water is not harmonized/standardized.
- Flavor Profile Analysis (FPA) commonly applied in diagnosis of T&O incidents, but it must be complemented by GC-O and GC-MS.
- Results of sensory tests may have large variability and uncertainty.