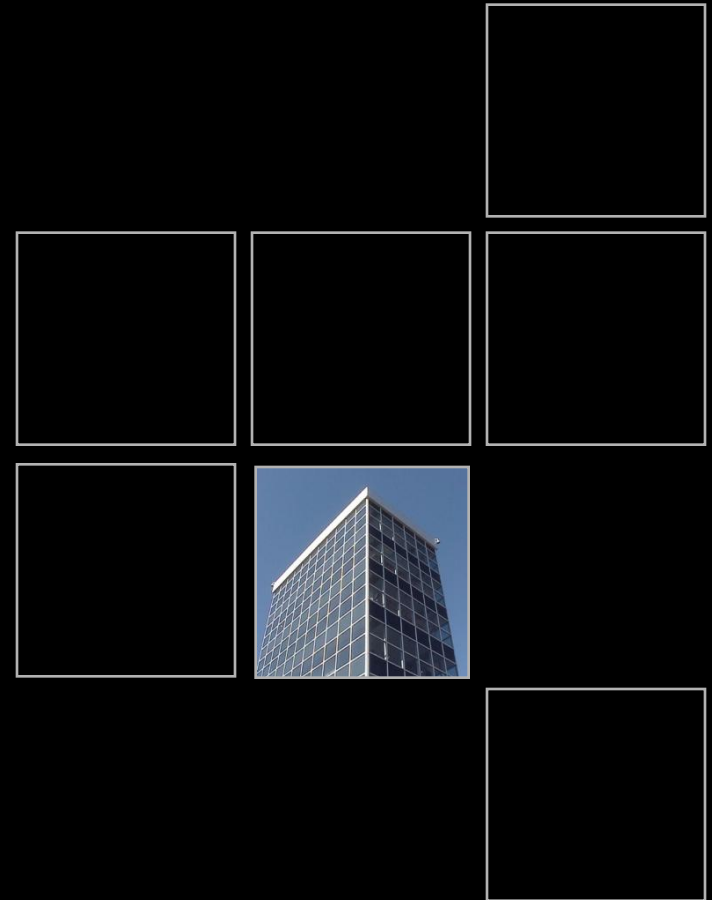


Role of sulphates and nitrates on the taste on water

Ricard Devesa

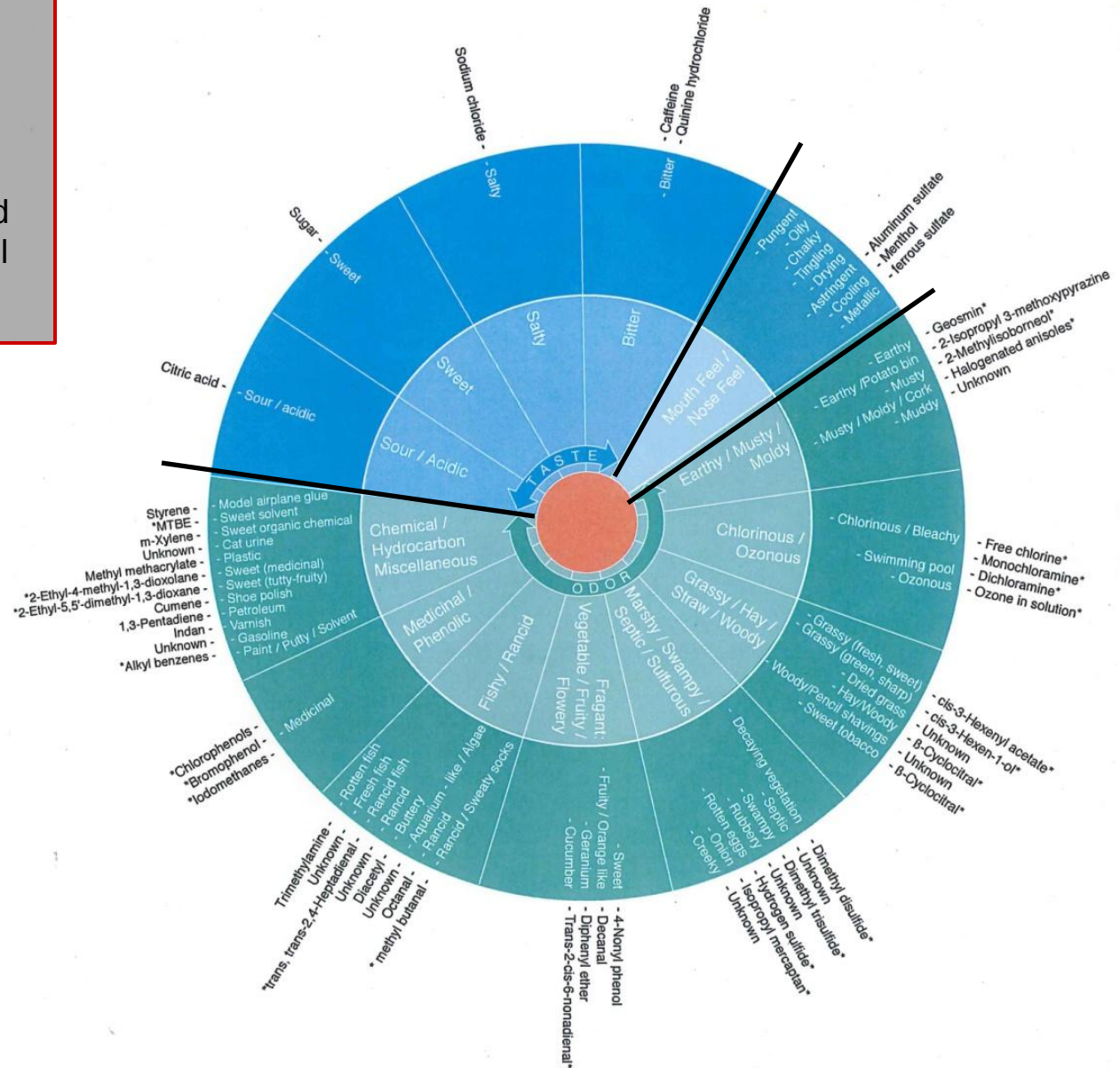


The taste-and-odour wheel

FPA

Flavour Profile Analysis
Standard Methods (AWWA)
2170 F.

Descriptive technique based
on the taste-and-odour wheel
of descriptors



Good or bad taste?

Ion	General Effect on Taste	Comment
Na^+	Unfavorable	Too much Na^+ causes poor tasting salty water.
K^+	Neutral	K^+ has low importance for taste and is generally at low mg/L concentrations in water.
Ca^{2+}	Favorable	Ca^{2+} can be optimised to make water taste good
Mg^{2+}	Neutral to unfavorable	Due to its typically low mg/L concentrations in natural waters, Mg^{2+} has less importance than Ca^{2+} for good taste. High Mg^{2+} concentrations can impart a bitter taste.
Cl^-	Unfavorable	Too much Cl^- can cause poor tasting water.
SO_4^{2-}		
HCO_3^-	Favorable	HCO_3^- should be optimised to make water taste good.
CO_3^{2-}	Unfavorable	Presence of CO_3^{2-} causes poor tasting water. Maintaining pH 7 to 8.5 will form HCO_3^- and improve taste.
NO_3^-	Neutral	NO_3^- has low importance for taste and is generally at low mg/L concentrations in water.

Source: R. Devesa, A. Zamyadi, J. Yu, R. Stuetz, T-F. Lin, and A. Dietrich. *Tastes, Odours and Algal Toxins in Drinking Water Resources and Aquaculture*. IWA SG report 2021 (in revision).

Usefulness T&O wheel

- * Summarize and classification of tastants and odourants in aquatic systems
- * Develop a common language for the water sector
- * Present the water sector with knowledge about the relevant species for T&O issues
- * Tool to solve T&O events (sensory analysis combined with chemical analysis)
- * Include the matrix “water” into the T&O catalogue wheels, and promote it at the sensory analysis field



TDS and liking



-0.23 liking units/100
mg/L TDS

(But some caveats i)

Última actualización: Febrero 2007

Devesa and Dietrich. *Guidance for Optimising Drinking Water Taste by Adjusting Mineralization as Measured by Total Dissolved Solids (TDS)*. Desalination 439 (2018) 147-154.

The antecedent

•PCA, MFA and PLS useful chemometric methods for taste studies in waters: general trends and discrimination among panelists

- TDS is the main parameter for water liking
- Bottled vs tap water: minerals have stronger effect than chlorine
- Positive effect: high pH, calcium, magnesium, bicarbonate, sulfate*, nitrate*, silica *
- Negative effect: sodium, potassium, chloride and chlorine

Platikanov, et al. *Influence of minerals on the taste of bottled and tap water: A chemometric approach*. Water Research 47 (2013) 693-704.

Platikanov et al. *Predicting consumer preferences for mineral composition of bottled and tap water*. Talanta, 162 (2017) 1-9.

Taste Threshold Conc (TTC)

3-AFC (Three Alternative Choice)

Taste Threshold Concentration (TTC)

Compound: sodium nitrate

Reference water: calcium bicarbonate, TDS= 100 mg/L

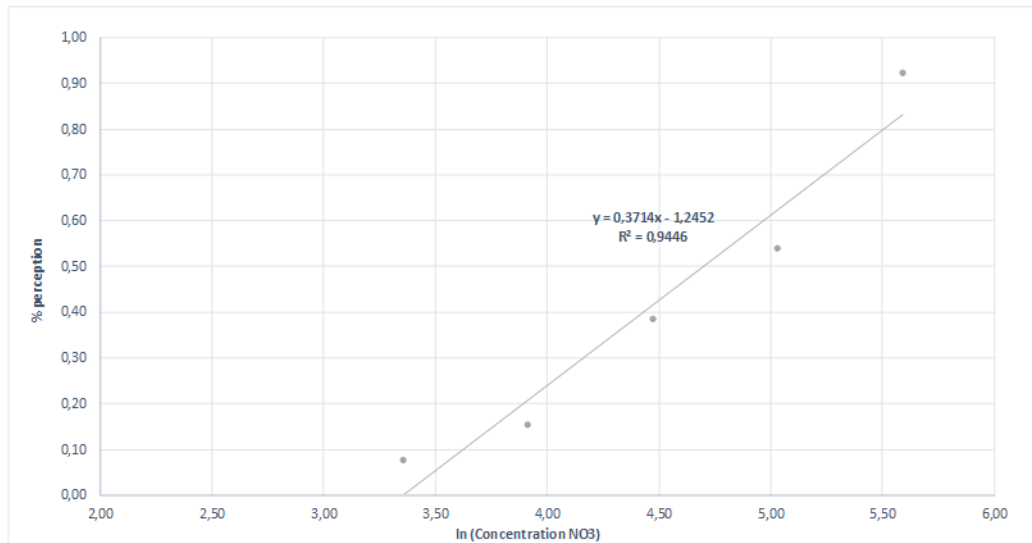
Temperature: 25 °C

Panel: trained

Factor: 1,75

Step	1	2	3	4	5	6	7	8	Geometric mean (mg/L)		
NO3 (mg/L)	16,30	28,60	50,00	87,50	153,00	268,00	469,00	820,00			
ln C	2,79	3,35	3,91	4,47	5,03	5,59	6,15	6,71		Correct answers	
Panelist 1									202,49	3	Session 1
Panelist 2									66,14	5	
Panelist 3									66,14	5	
Panelist 4									202,49	3	
Panelist 5									115,70	4	
Panelist 6									202,49	3	
Panelist 7									115,70	4	Session 2
Panelist 8									354,53	2	
Panelist 9									202,49	3	
Panelist 10									21,59	7	
Panelist 11									66,14	5	
Panelist 12									202,49	3	
Panelist 13									37,82	6	

Media geométrica Unbral global 110,86 mg/L NO3



50% perception :	109,90 ppm NO3
25% perception :	56,06 ppm NO3
75% perception :	215,46 ppm NO3

1

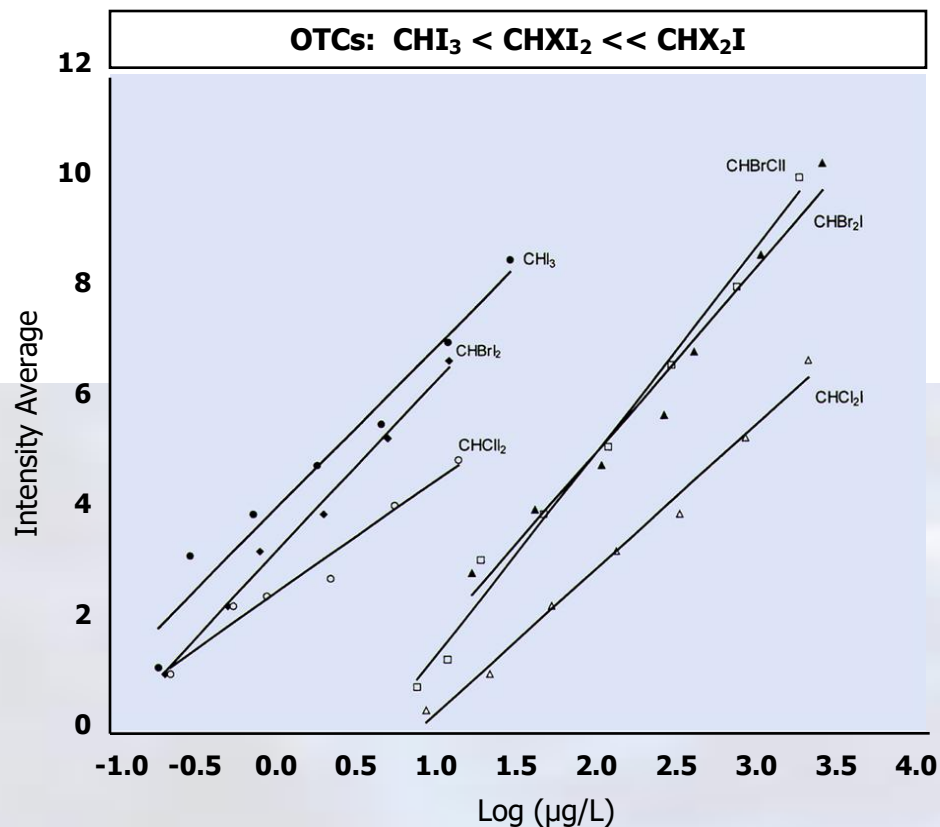
Nitrate thresholds (TTC)

Nitrate TTC: clearly above the PV

Ion	Co-ion	Reference water	Number panellists	Geometric Mean	50 % Perception	75 % Perception
Nitrate	Sodium	Calcium bicarbonate 100 mg/L TDS	13	111 mg/L	110 mg/L	215 mg/L
Nitrate	Calcium	Sodium bicarbonate 100 mg/L TDS	15	100 mg/L	100 mg/L	281 mg/L

But other methods are used ...

Iodinated trihalomethanes



Descriptors: medicinal, sweet, perfumed.

Weber-Fechner plots of individual iodinated trihalomethanes obtained by FPA analysis.

From: Odor Threshold Concentrations of Iodotrihalomethanes. J. Agric. Food Chem., Vol. 49, N° 4, 2001

Sulphate thresholds (TTC)

Ion	Co-ion	Reference water	n	Geometric Mean	50 % Perception	75 % Perception
Sulphate	Sodium	Calcium bicarbonate 100 mg/L TDS	13	159 mg/L	167 mg/L	282 mg/L
Sulphate	Calcium	Sodium bicarbonate 100 mg/L TDS	14	83 mg/L	71 mg/L	178 mg/L

Sulphate TTC's

Results obtained were below or around the usual reference value of 250 mg SO₄/L. They were clearly lower than values in the literature.



Role of sulphate. Duo-trio with preference

Moderate levels of sulfate improve the taste ;

(a) TDS = 100 mg/L Sodium sulphate

Step	1	2	3	4	5	6
Conc. SO ₄ (mg/L)	100	150	225	337	506	759
Panelist 1						
Panelist 2		X				
Panelist 3						
Panelist 4		X	X			
Panelist 5	X	X	X			
Panelist 6						
Panelist 7						
Panelist 8						
Panelist 9						
Panelist 10		X				
Panelist 11	X	X				

(b) TDS = 260 mg/L Sodium sulphate

Step	1	2	3	4	5	6
Conc. SO ₄ (mg/L)	100	150	225	337	506	759
Panelist 1	X					
Panelist 2						
Panelist 3			X	X		
Panelist 4						
Panelist 5	X					
Panelist 6						
Panelist 7	X					
Panelist 8	X	X				
Panelist 9			X			

(c) TDS = 100 mg/L Calcium sulphate

Step	1	2	3	4	5	6
Conc. SO ₄ (mg/L)	80	120	180	270	405	607.5
Panelist 1						
Panelist 2	X					
Panelist 3						
Panelist 4						
Panelist 5						
Panelist 6						
Panelist 7						
Panelist 8	X					
Panelist 9						

(d) TDS = 260 mg/L Calcium sulphate

Step	1	2	3	4	5	6
Conc. SO ₄ (mg/L)	80	120	180	270	405	607.5
Panelist 1		X	X			
Panelist 2						
Panelist 3						
Panelist 4						
Panelist 5						
Panelist 6	X					
Panelist 7						
Panelist 8						
Panelist 9	X					
Panelist 10			X			

Uncorrect answer.

Correct answer. Odd sample (spiked with sulphate) likes more

Correct answer. No preference between samples

Correct answer. Odd sample (spiked with sulphate) dislikes more

	Sodium sulphate	Calcium sulphate
TDS = 100 mg/L	198 mg/L	176 mg/L
TDS = 260 mg/L	210 mg/L	259 mg/L

Appearance of negative influence of sulphate

Surface Disinfectant

- Geosmin*
- 2-Isopropyl 3-methoxy-pyrazine
- 2-Methylisoborneol*
- Halogenated anisoles*
- Unknown

Bleach

- Free chlorine*
- Monochloramine*
- Dichloramine*
- Ozone in solution*

Swimming Pool Disinfectant

- cis-3-Hexenyl acetate*
- cis-3-Hexen-1-ol*
- Unknown
- Cycloctral*
- Known cycloctral*

Drinking Water Disinfectant

- Chlorine*
- Chloramines*
- Ozone*
- Ultraviolet*
- Copper-silver ionization*
- Activated carbon*
- Membrane filtration*
- Other



Step	1	2	3	4	5	6
Conc. S04 (mg/L)	80	120	160	270	405	607.5
Patient 1						
Patient 2	X					
Patient 3						
Patient 4						
Patient 5						
Patient 6						
Patient 7						
Patient 8	X					
Patient 9						

Step	1	2	3	4	5	6
Cost, \$/GJ (mg/L)	80	120	150	270	405	607.5
Parasetol 1		X	X			
Parasetol 2						
Parasetol 3						
Parasetol 4						
Parasetol 5						
Parasetol 6	X					
Parasetol 7						
Parasetol 8						
Parasetol 9	X					
Parasetol 10			X			

Correct answer. Odd sample (spiked with sulphate) dislikes more

Discussion of USEPA SMCL's

Dietrich and Burlingame. *Critical review and rethinking of USEPA secondary standards for maintaining organoleptic quality of drinking water*. Environmental Science and Technology, 49(2) (2015).

Parameter	Effect on taste	SMCL			Candidates for SMCL
		Value	Consistent	Reassessment recommended	
Chloride (Cl)	Salty	250 mg/L		High correlation with sodium, primary cause of salty taste	
Copper (Cu)	Metallic	1.0 mg/L		TTC about 0.4 – 0.8	
Iron (Fe)	Metallic	0.3 mg/L		TTC for Fe(II): 0.03 – 0,17 mg/L	
Manganese (Mn)	Metallic (?)	0.05 mg/L	* (1)		
* Sulfate (SO ₄)	Salty taste, gypsum aft.	250 mg/L	*		
TDS	Salty	500 mg/L	*		
Zinc (Zn)	Metallic	5.0 mg/L	*		
Sodium (Na)	Salty	---			
Ammonia (NH ₃)	Pungent (also odor)	---			Distribution of ammonia species depends on pH. Research needed
Hardness	Bitter at high concs	---			< 150 mg/L CaCO ₃ targeted for scaling
Sodium	Salty	---			30 – 60 mg/L affects taste

(1) Staining and color detection at 0.01 – 0.02 mg/L

Sulphates give water a bad taste. Really?

Thanks for your attention

