Recursos Hídricos Impacto antropogénico: Avaliação, Tratamento e Reciclagem

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GRUPO RADIAÇÃO, ELEMENTOS E ISÓTOPOS

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radiações elementos e isótopos

UN Development Goals – SDG (2015-2030)

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

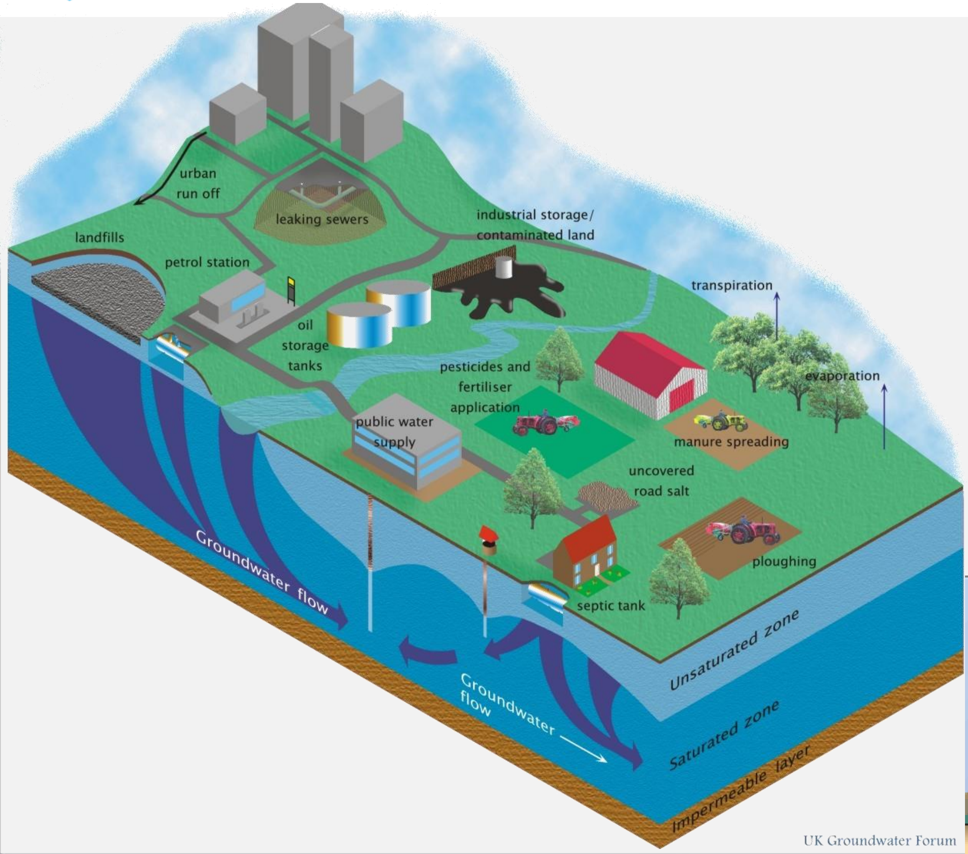
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

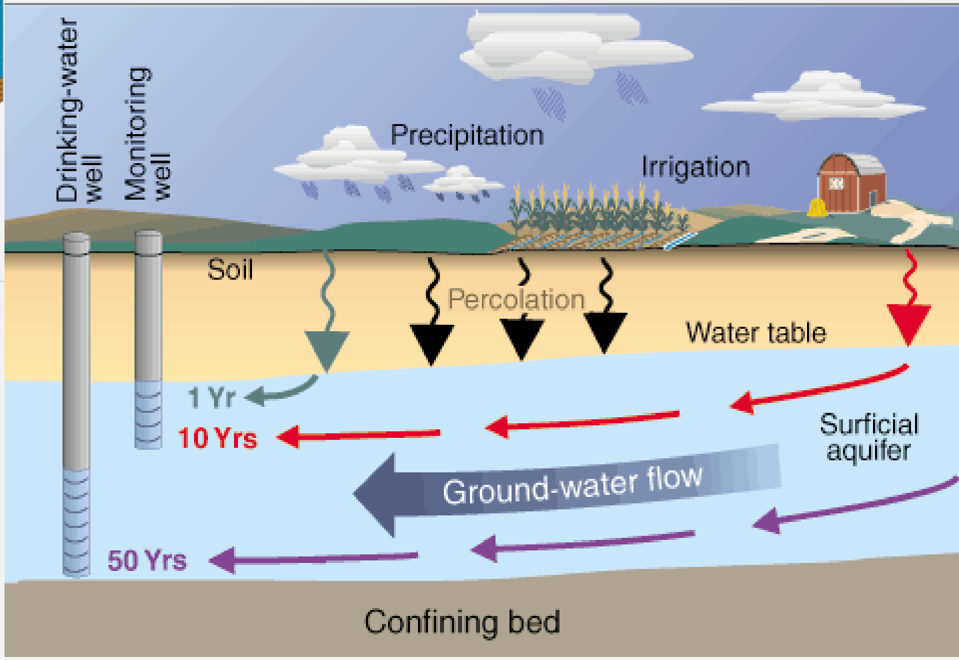
6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies

6.b Support and strengthen the participation of local communities in improving water and sanitation management

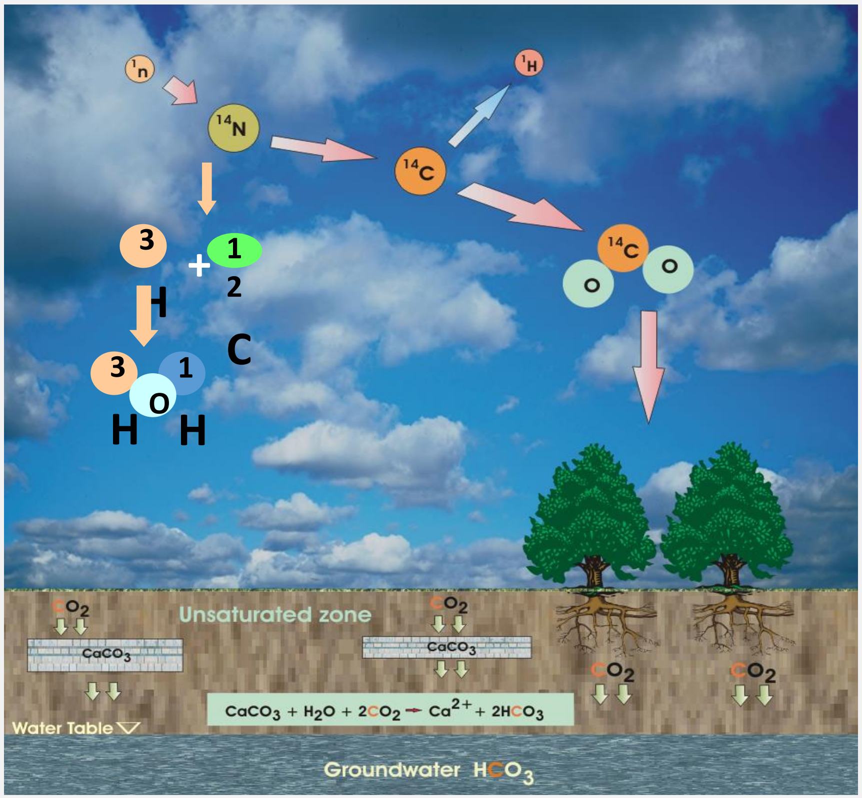
WATER CYCLE



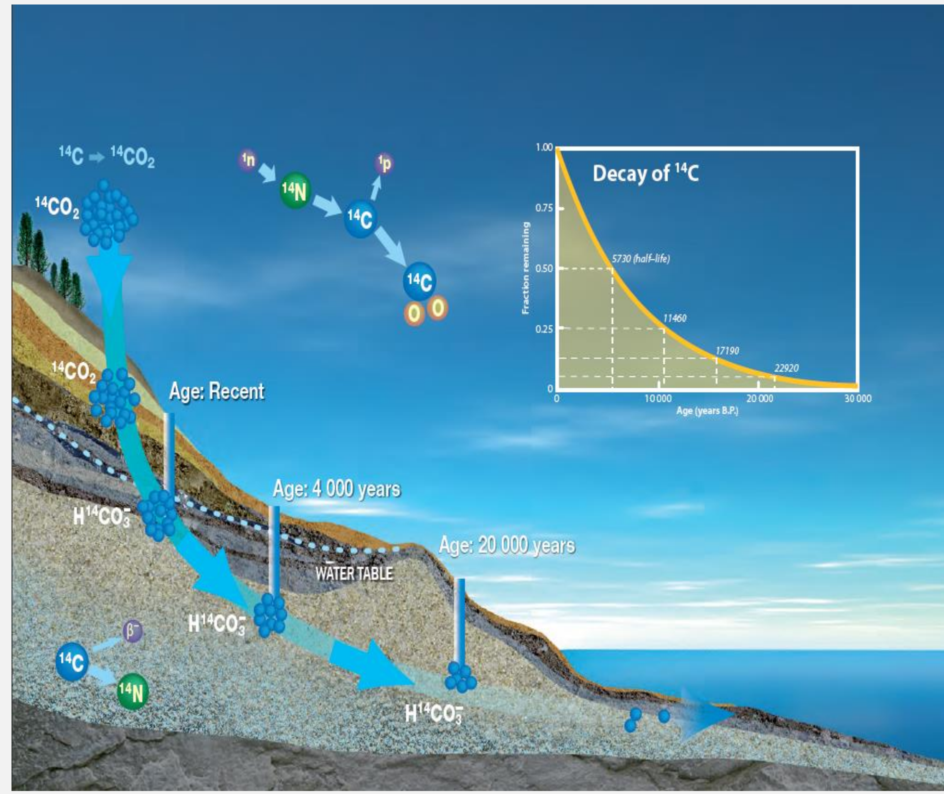
Potential contamination sources of superficial and groundwater systems



C-14 and Tritium (^{3}H) in nature



Decay of ^{14}C allows groundwater dating

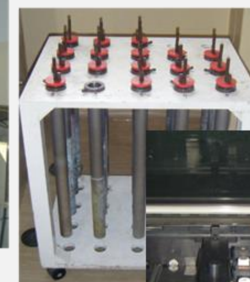


"Classical" dating tool for gw recharged between 2 and 40 kyr

Isotope Hydrology techniques @ C2TN


Stable isotopes ($\delta^{18}O$, $\delta^{2}H$)



Tritium (^{3}H)

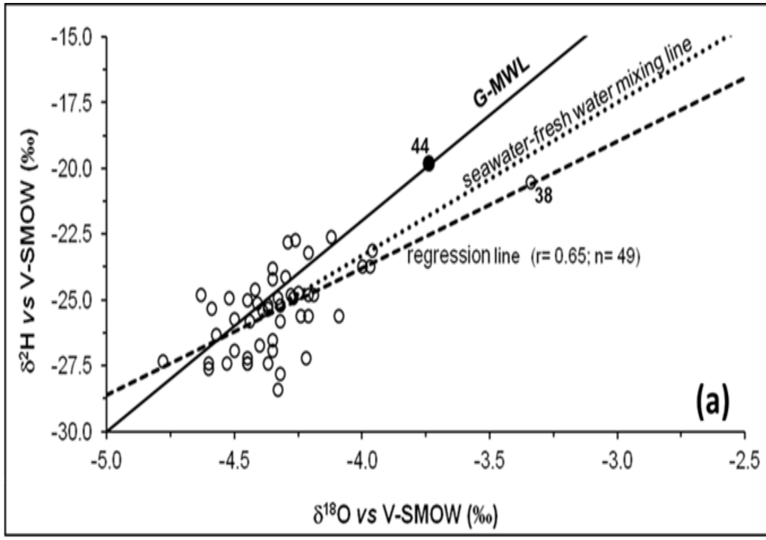


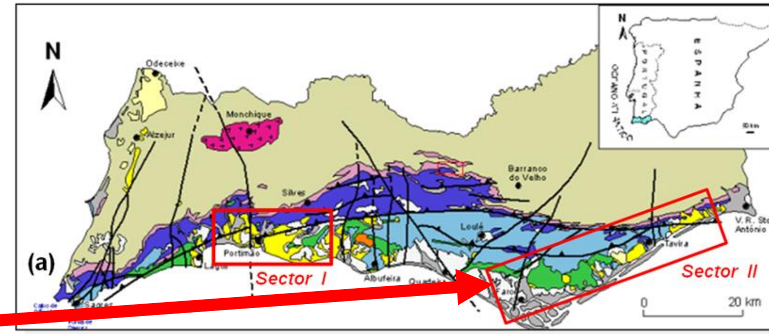

Carbon- 13 ($\delta^{13}C$)

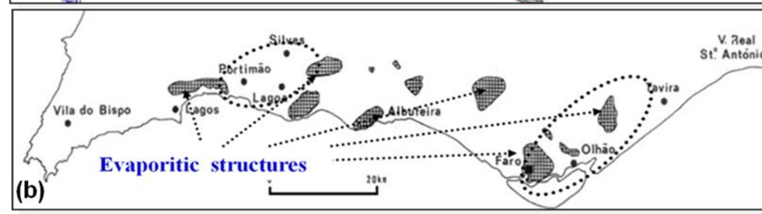


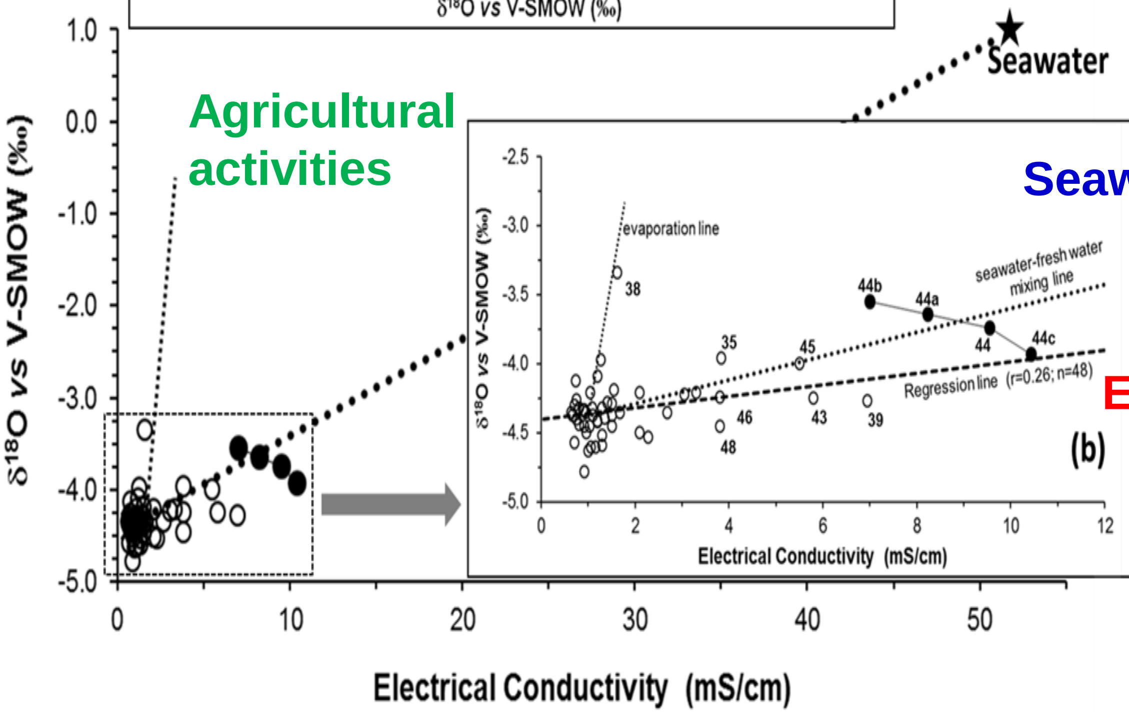
Carbon- 14 (^{14}C)

Stable isotopes in the identification of salinization processes







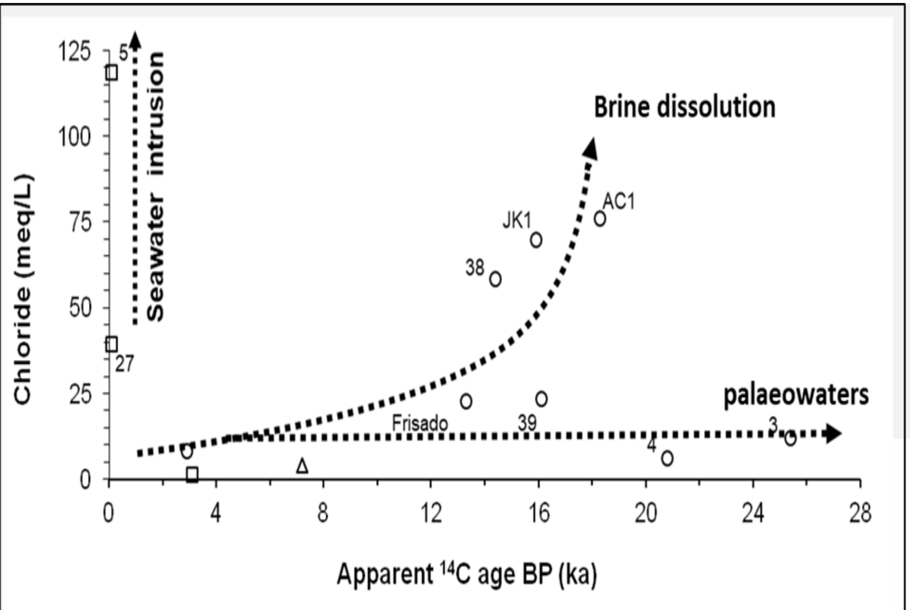


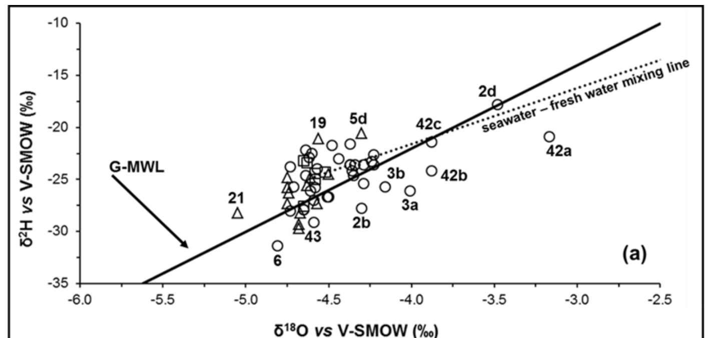
Agricultural activities

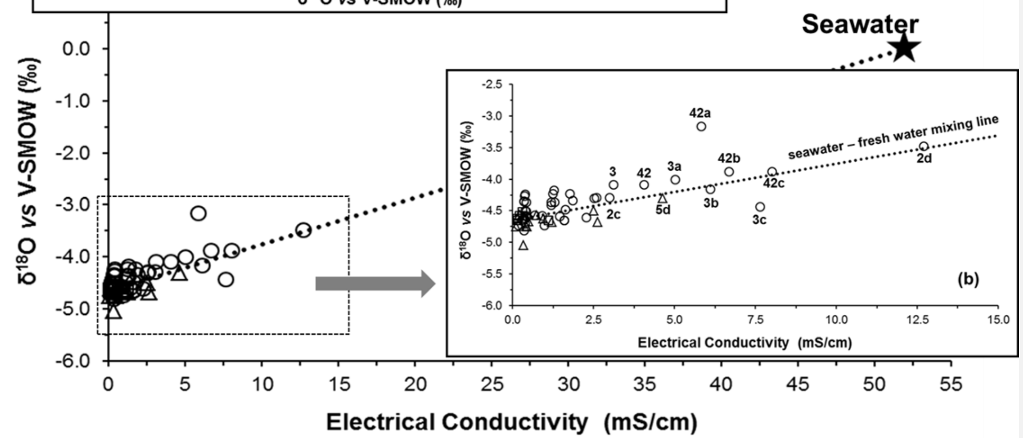
Seawater intrusion

Evaporites dissolution

Groundwater dating as a tool in the identification of groundwater resources degradation







BACKGROUND

- Portugal and Spain are the main producers of cork in the world,
- Portuguese exportation represents almost **70% of world market**,
- The cork process generates **large quantities of wastewater**, mainly the boiling of the cork planks.

↓

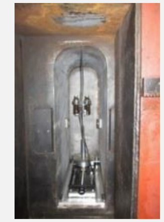
- Aqueous dark liquor
- Low pH
- High Chemical Oxygen Demand (COD)
- Low biodegradability (BOD)
- High concentration of undesirable cork extracts such as phenolic acids and tannins and 2,4,6-trichloroanisole

Difficult to degrade by conventional treatments

↓

TREATMENT AND VALORIZATION!

INFRASTRUCTURES @ C2TN

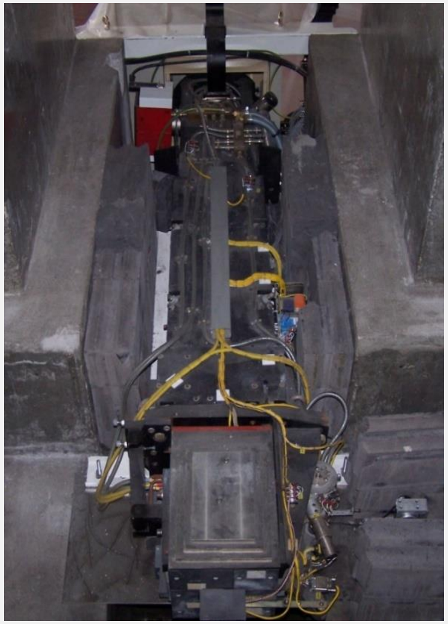


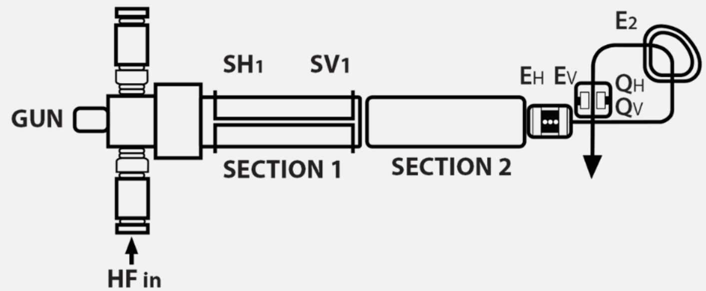
^{60}Co Experimental Irradiator - PRECISA 22
(Graviner, Lda, UK -1971)
Activity of 2.8 kCi
Maximum Dose rate: 1.2 kGy/h

Ionizing radiations facility - IRIS

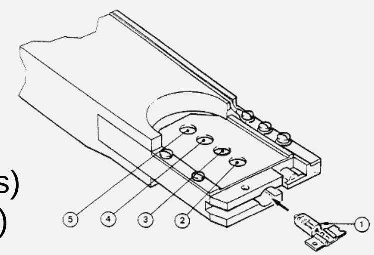
LINEAR ELECTRON ACCELERATOR (LINAC)

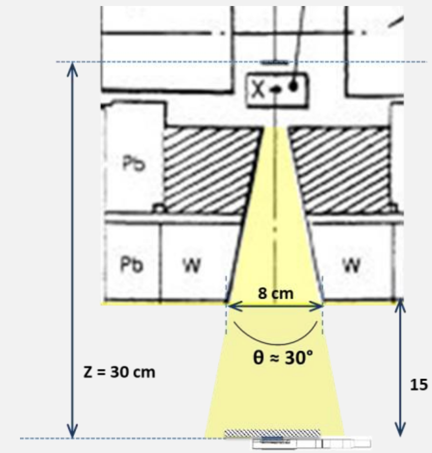
Clinical LINAC GE Saturne 41 converted for industrial and research use (installed in late 2009)

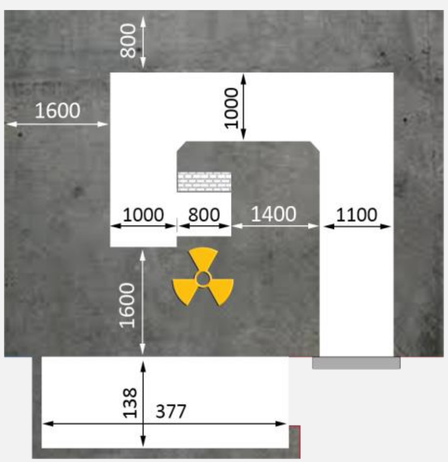




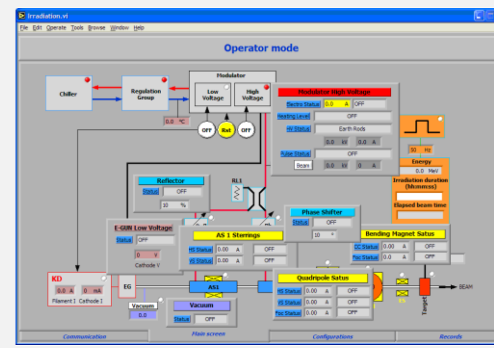
1 – simulation lamp
2 – electron (pre-scatter)
3 – (not used)
4 – high energy target (photons)
5 – low energy target (photons)





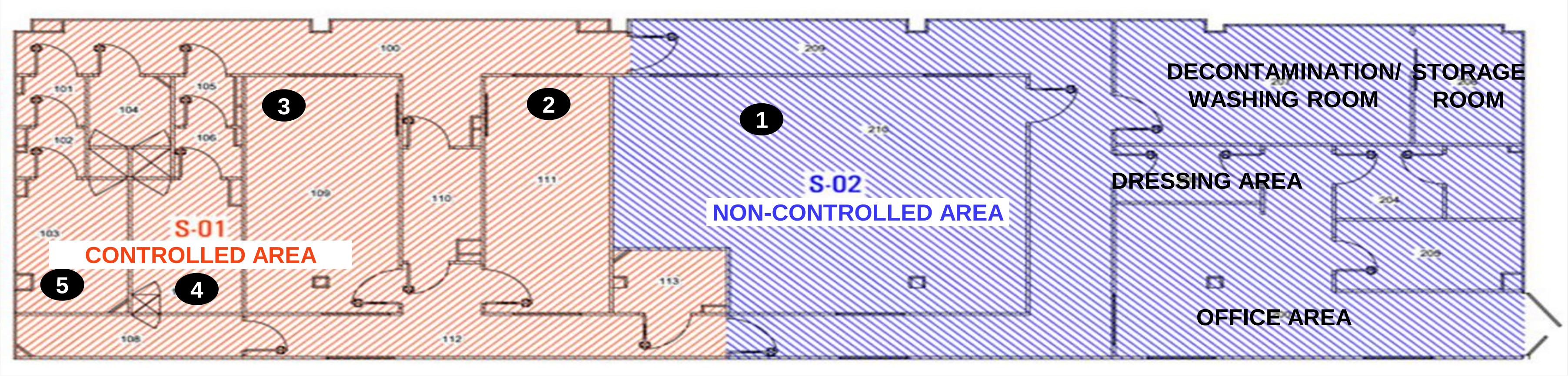


Electron beam	**10 MeV**
Photon beam (tungsten target)	**8-12 MeV**
Pulse width	**4 μs**
Pulse repetition frequency	**10-150 Hz**



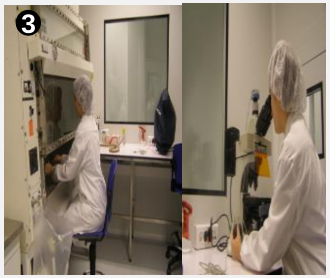
Beam E - 10 MeV - 0.3kGy - 5 mn	0.3 kGy in 5 mn - 50mA - 2.28μs
Beam E - 10 MeV - 21.3kGy - 5 mn	21.3 kGy in 5 mn - 50mA - 2.84μs
Beam E - 10 MeV - 4.2kGy - 5 mn	4.2 kGy in 5 mn - 50mA - 2.8μs
Beam E - 10 MeV - 42.6kGy - 5 mn	42.6kGy in 5 mn - 50mA - 2.84μs
Beam E - 10 MeV - 63.9kGy - 5 mn	63.9 kGy in 5 mn - 50mA - 2.84μs
Beam X - 10MeV	7.13Gy/mn - 58.6mA - 2.8μs
Beam X - 11MeV	9.5GyMmn - 58.6mA - 2.8μs
Beam X - 12MeV	8.7 Gy/mn - 42.4mA - 2.72μs
Beam X - 8MeV	2.8Gy/mn - 50.8mA - 2.2μs
Beam X - 9MeV	4.3y/mn - 54mA - 2.36μs
Beam X -12MeV	6.2Gy/mn - 30mA - 2.72μs

LETAL – Laboratory of Technological Assays in Clean Rooms



Sterility assays
ISO 5

Virology room
BSL 2 Lab - ISO 5



Microbiology room
BSL 1 lab - ISO 7

Molecular Biology room
ISO 7

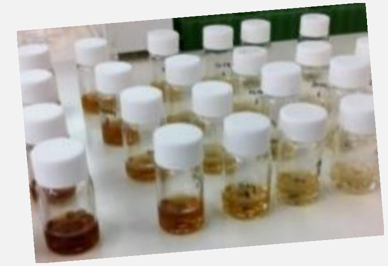
Analytical room

Decontamination room

CORK WASTEWATER TREATMENT & VALORISATION

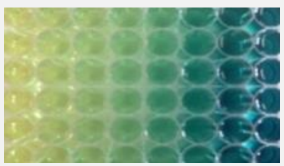
Parameter	Average
pH	5.14
COD ($mgO_2\ L^{-1}$)	2903
BOD_5 ($mgO_2\ L^{-1}$)	394
Biodegradability, BOD_5/COD	0.136
TP (mg gallic acid L^{-1})	680
TSS (mg L^{-1})	134

J. Madureira et al., Water Science & Tecnhology, 2013, 67.2: 374.

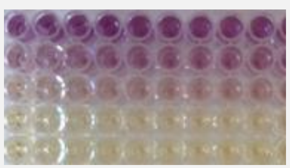


GAMMA RADIATION EFFECTS

% COD variation	% BOD variation	% TSS variation	% TP variation
9%	-86%	-45%	21%
Increase of oxidable organic matter	Decrease of organic matter content	Increase of chemical species soluble in water	Degradation of large molecules into small molecules



Reducing Power



DPPH scavenging activity

β - Carotene bleaching inhibition

J. Madureira et al., Chemosphere, 2017, 169: 139.

INCREASE OF ANTIOXIDANT ACTIVITY!!

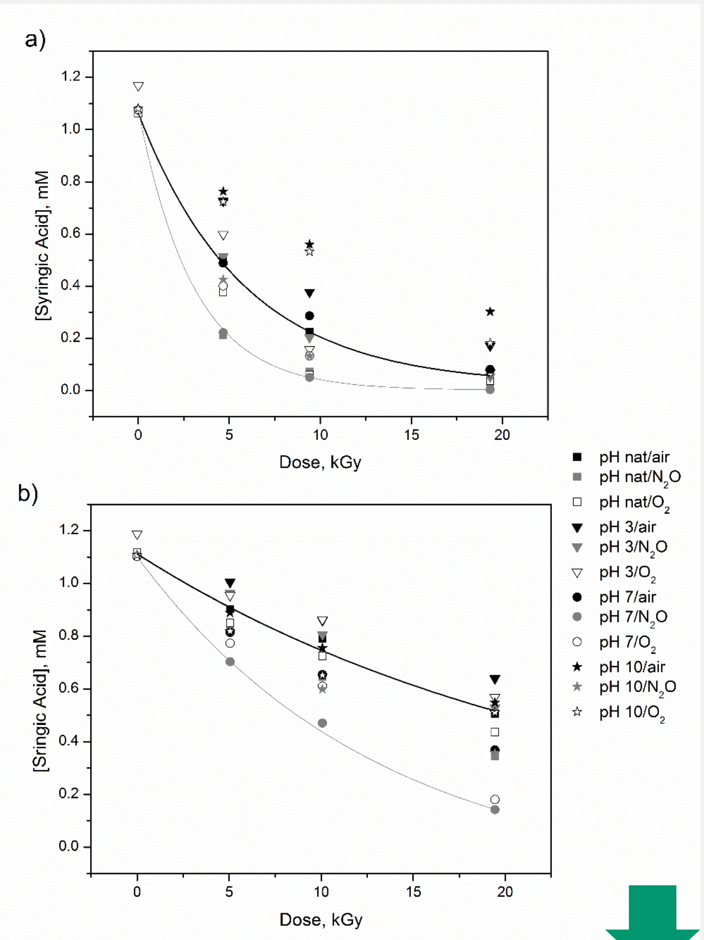
Samples	0 kGy	20 kGy	50 kGy	100 kGy
Antioxidant activity (EC_{50}, μg/mL)				
DPPH scavenging activity	180 ± 12[a]	151 ± 4[b]	133 ± 2[c]	119 ± 6[d]
Reducing power	102 ± 0[a]	90 ± 2[b]	80 ± 1[c]	68 ± 1[d]
β - Carotene bleaching inhibition	207 ± 6[a]	255 ± 4[b]	150 ± 6[c]	79 ± 4[d]

Antioxidant activity of cork wastewater samples, non-irradiated and irradiated at different doses. In each row, different letters mean significant differences between average values ($p < 0.05$).

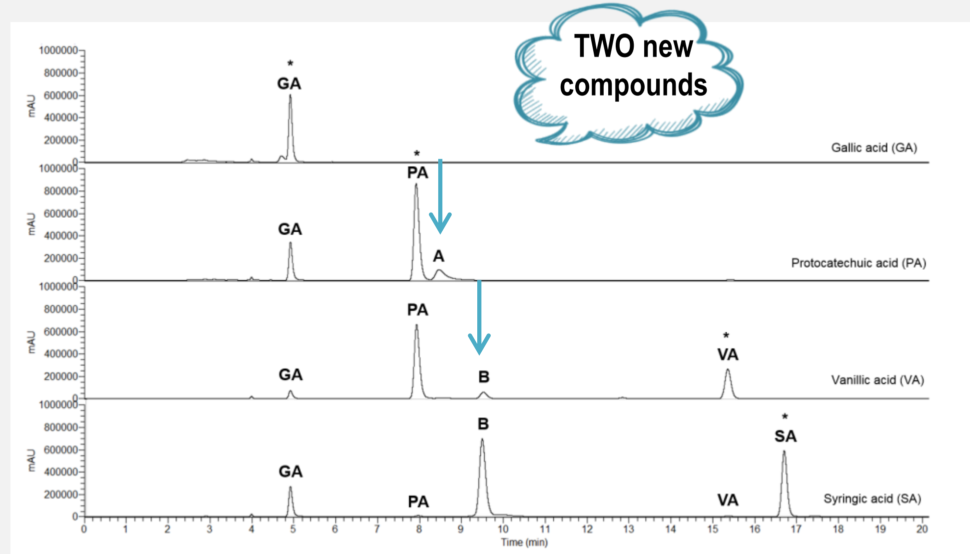
INCREASE OF THE ADDED-VALUE!

Cork wastewater Treatment & Valorisation

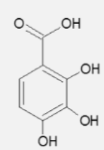
Syringic acid average concentration decay (n=2) by gamma radiation under different pH and atmosphere conditions: a) isolated compound solution and b) quaternary mixture solution. Exponential fit: black line – aerated solution at natural pH; grey line – best degradation condition



Degradation studies & Radiolytic Products Identification

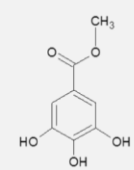


Individual chromatograms of the isolated compounds solutions irradiated at 20 kGy, recorded at 280 nm. Peak GA – gallic acid; Peak PA – protocatechuic acid; Peak VA – vanillic acid; Peak SA – syringic acid; Peaks A and B – detected radiolytic products. The symbol * refers to the compound that is being studied.



A

2,3,4-trihydroxybenzoic acid



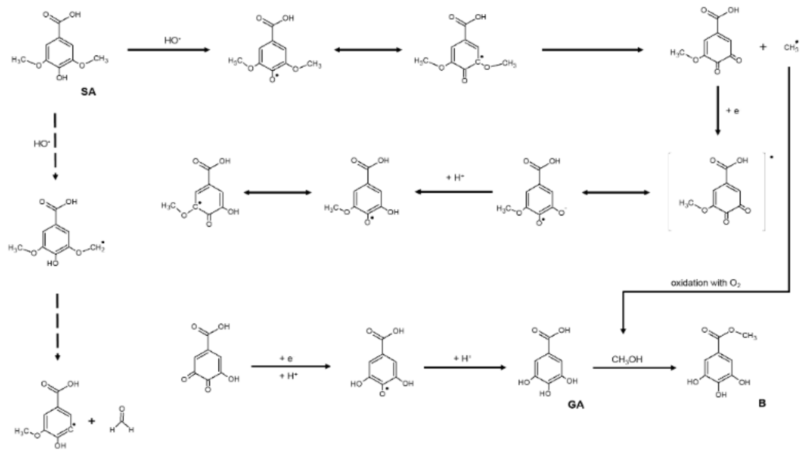
B

Methyl gallate

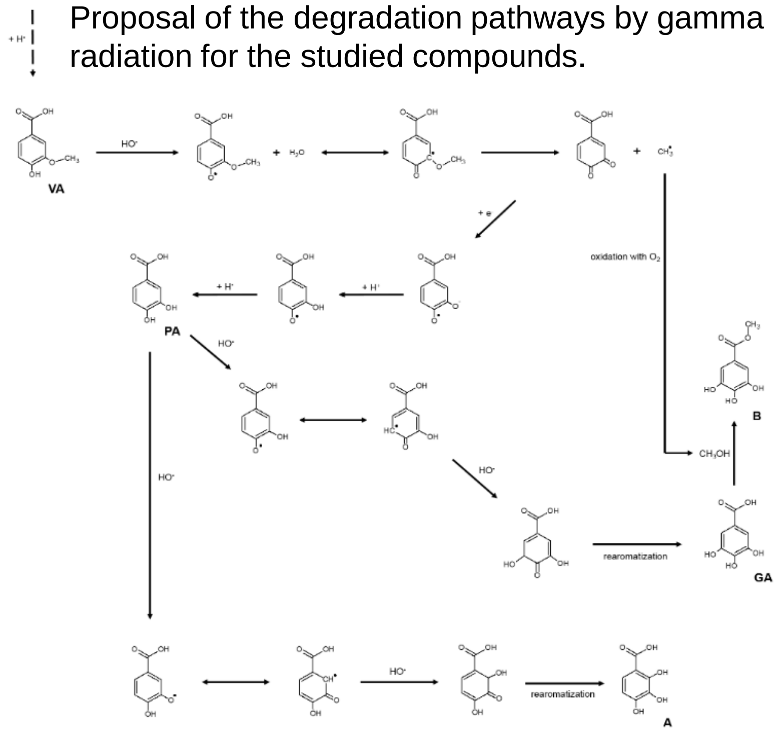
J. Madureira et al., Chemical Engineering Journal, 2018, 341: 227.

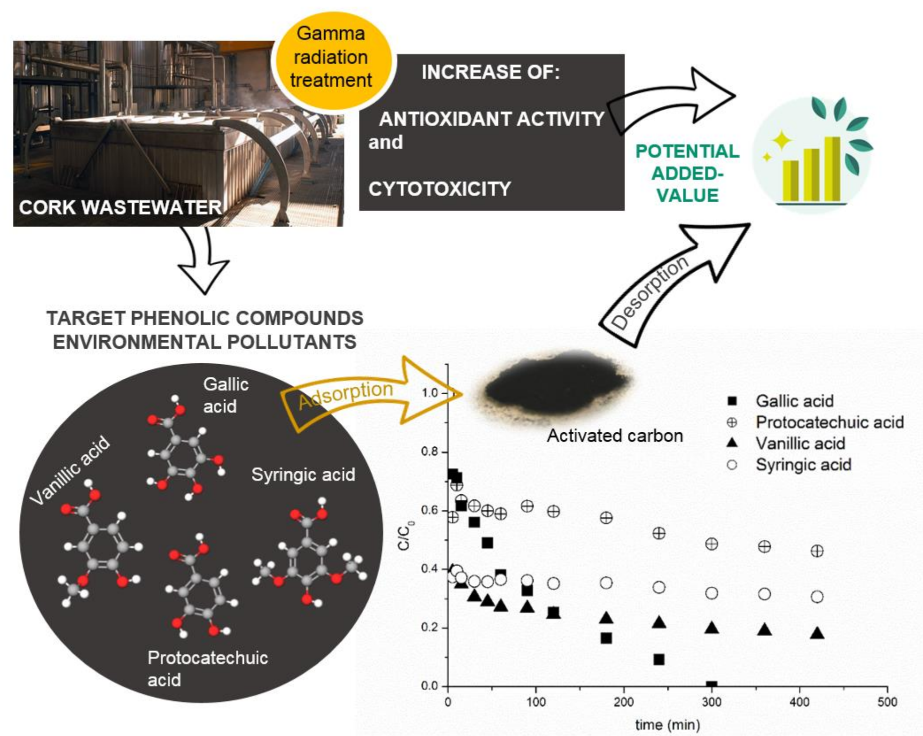
IONIZING RADIATION AT 20 kGy COULD BE APPLIED FOR CORK WASTEWATER TREATMENT.

CORK WASTEWATER TREATMENT & VALORISATION



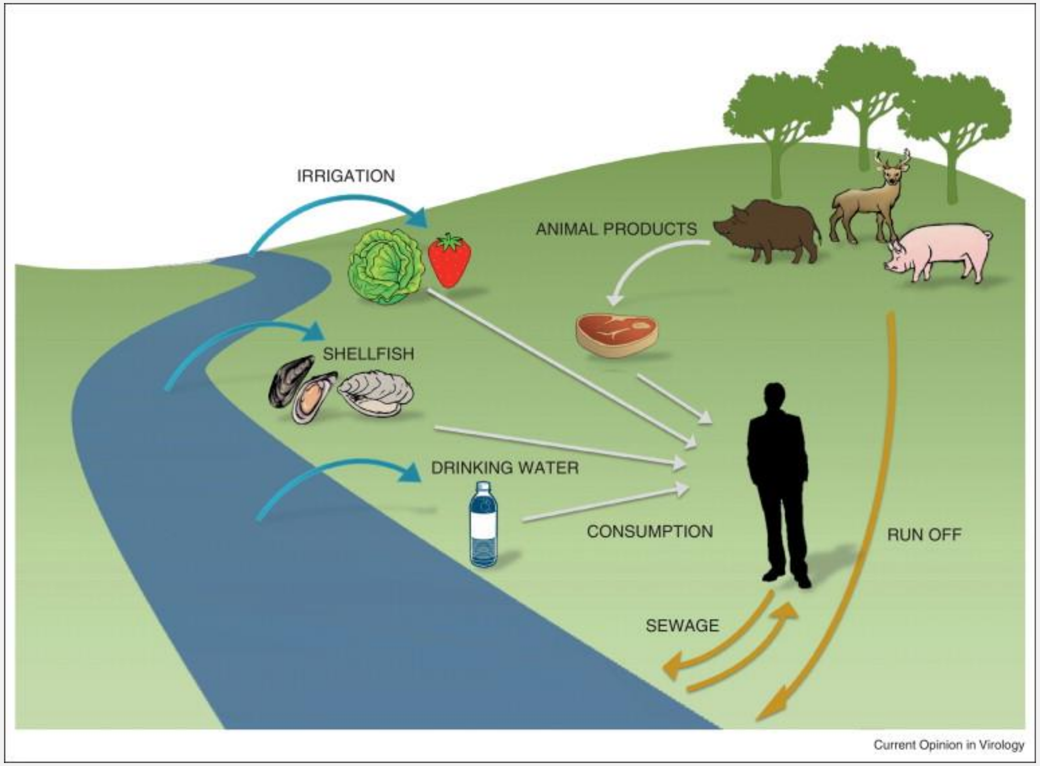
Proposal of the degradation pathways by gamma radiation for the studied compounds.





J. Madureira et al., Water Science & Tecnhology, 2018, 77.2: 456.

VIRUSES HAS EMERGED AS ENVIRONMENTAL CONTAMINANTS

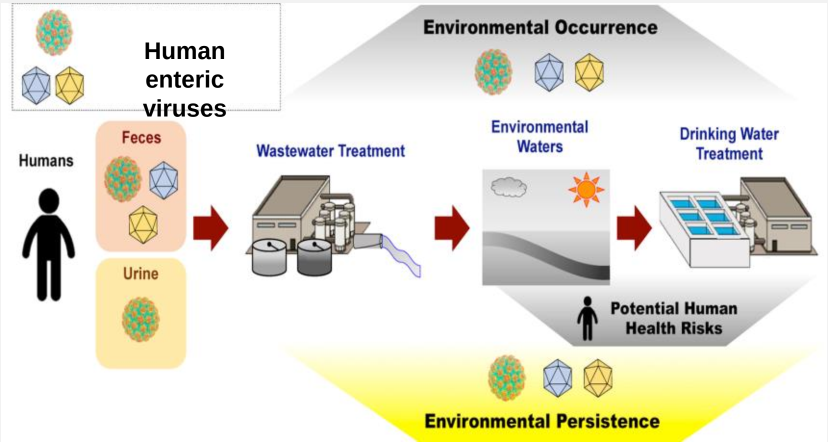


Enteric viruses, can enter the environment through the discharge of waste from infected individuals and contaminate drinking and recreational waters or fresh food products, and be transmitted back to susceptible individuals to continue the cycle of infection.

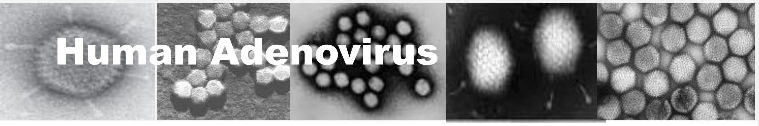
Enteric viruses are inherently resistant to conventional treatments and common disinfectants, persisting in the environment.

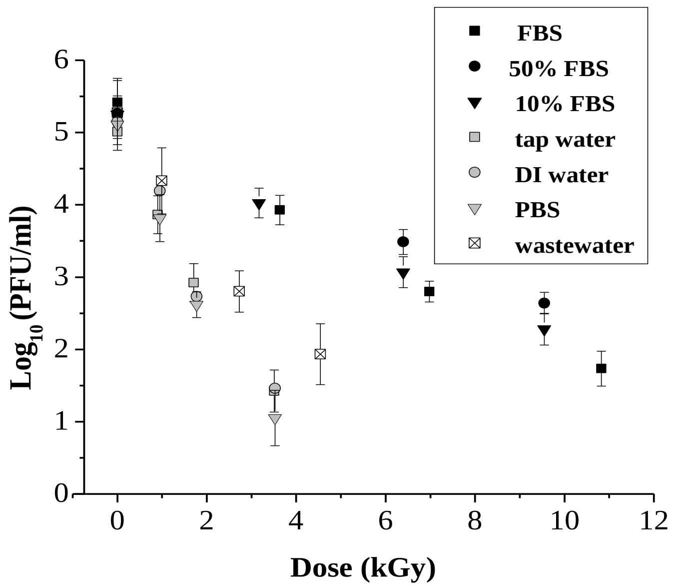
⇩

Other virucidal technologies must be investigated



Environmental Protection - Biohazards

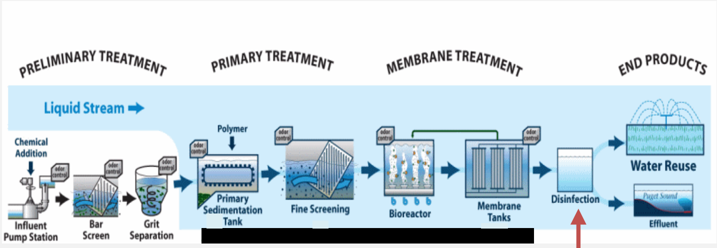


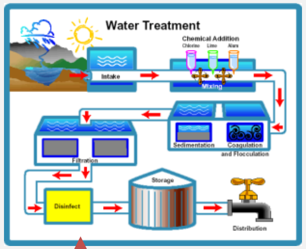


Survival curves to gamma radiation of human adenovirus type 5 (HAdV-5) for several suspension matrices: phosphate-buffered saline (PBS), deionized filtered water (DI water), tap water, fetal bovine serum (FBS), and wastewater collected from a municipal wastewater treatment plant before tertiary treatment.

Matrix and dose rate influence the response of microorganisms to gamma radiation and could be also important factors for bioremediation.

S. Cabo Verde et al., Radiation and Environmental Biophysics, 2016, 55:125.





Ionizing radiation

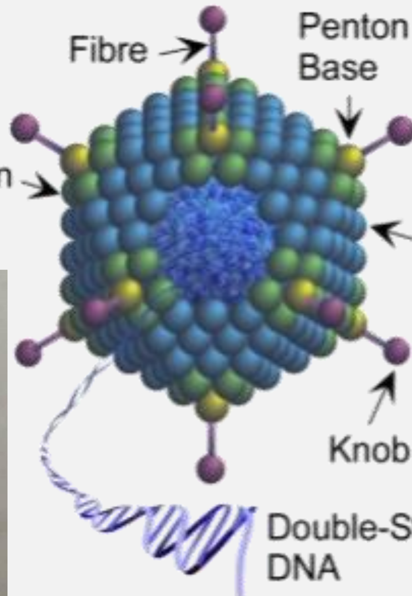
Virucidal efficiency of 99.99% for gamma irradiation at 6 kGy for tap water and wastewater.

A. I. Pimenta et al., Applied and Environmental Microbiology, 2016, 82:5166.

VIRUCIDAL MECHANISMS OF IONIZING RADIATION ?

Studies suggest that viruses are the masters of evolution and innovation in the web of life. They are the simplest organisms with the capacity of using the lowest energy to conserve life and its diversity.

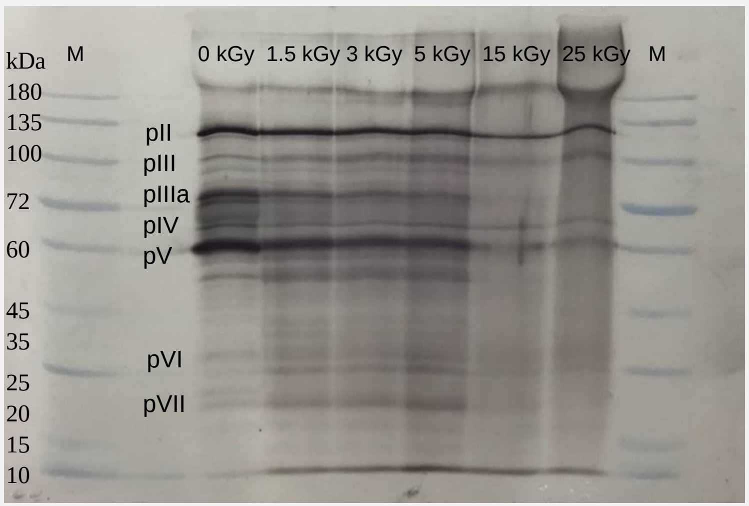
Human Adenovírus



Capsid

Genome

Western Blot

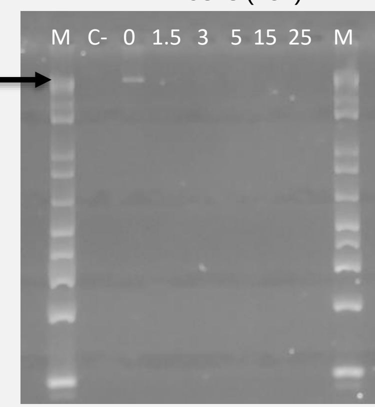


Legend: Major proteins - hexon (pII); penton (pIII); fiber (pIV) and minor proteins - pIIIa, pVI and core proteins – pV, pVII.

LONG RANGE PCR AMPLIFICATION

DOSES (KGY)

Fragment size: 10107 bp



1% agarose electrophoresis stained with gel red

- Results suggested degradation of capsid proteins at doses of 15 kGy and 25 kGy.
- Amplification of the 10-kb fragment was inhibited at low doses (1.5 kGy).

ACKNOWLEDGEMENTS

- **International Atomic Energy Agency (IAEA, Austria):**

CRP F23029 - Radiation Treatment of Wastewater for Reuse with Particular Focus on Wastewaters Containing Organic Pollutants.

Research Contract 17474 – Survival and inactivation patterns of viral threat agents in the environment: assessment of ionizing radiation as decontamination tool.

CRP F23033 - Radiation Inactivation of Bio-Hazards using High Powered Electron Beam Accelerators

- **Portuguese Foundation of Science and Technology (FCT, Portugal):**

RECI/AAG-TEC/0400/2012 "*Application of Ionizing Radiation for a Sustainable Environment*" project.

EXPL/DTP-SAP/2338/2013 "Inactivation patterns of enteric virus by ionizing radiation" project.

UID/Multi/04349/2013 project (C2TN/IST).

- **AMORIM Industrial Solutions - Indústria de Cortiça e Borracha S.A.**
- **Municipal Wastewater Treatment Plant from Barreiro, Portugal.**

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL PORTUGAL 2007.2013

COMPETE
PROGRAMA OPERACIONAL FACTORES DE COMPETITIVIDADE

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Thank you for your attention

RADIATION FOR SCIENCE AND SOCIETY

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