Electronic Supplementary Information

for

Dissolution-based uptake of CeO_2 nanoparticles by freshwater shrimp – A dual-radiolabelling study of the fate of anthropogenic cerium in water organisms

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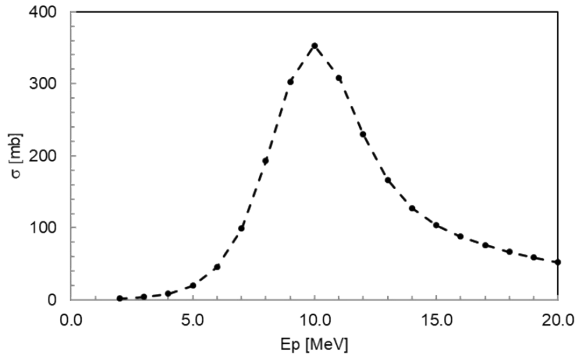

Fig. SI1: Reaction cross section for the La-139(p,n)Ce-139 nuclear reaction (C.Vermeulen, G.F.Steyn, F.M.Nortier, F.Szelecsenyi, Z.Kovacs, S.M.Qaim, Nucl. Instrum. Methods in Physics Res., Sect.B, Vol.255, p.331, 2007).

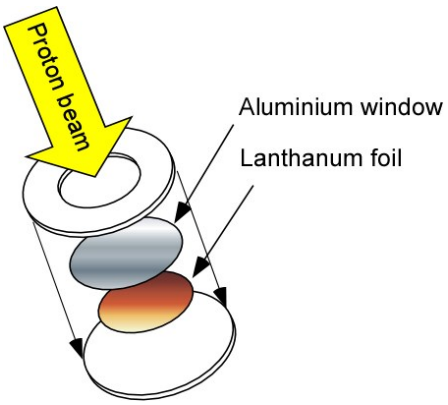

Fig. SI2: Target design for Ce-139 production.

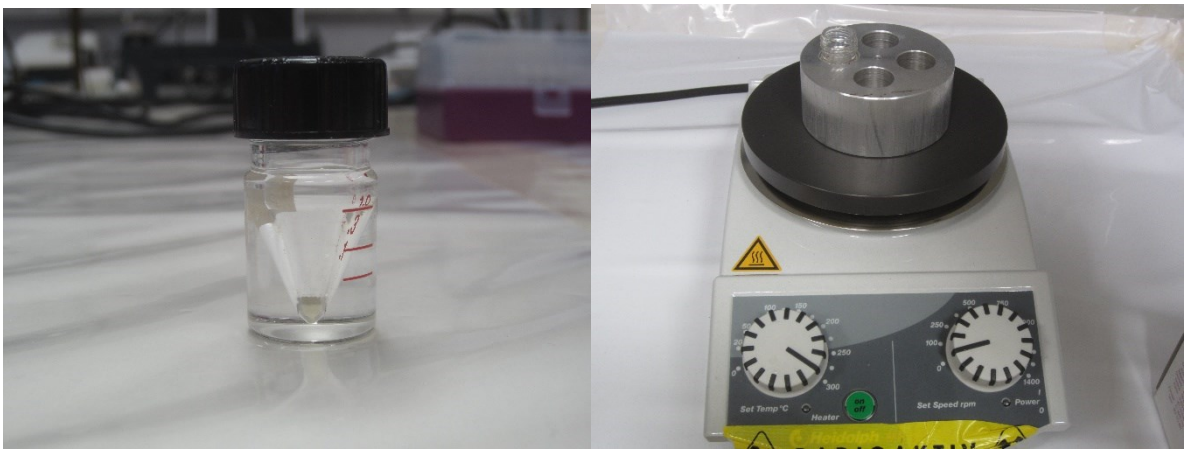

Fig. SI3: Experimental setup for in-diffusion labelling.

Fig. SI4: Two shrimp in experimental vial with 10 mL of moderately hard standard water.

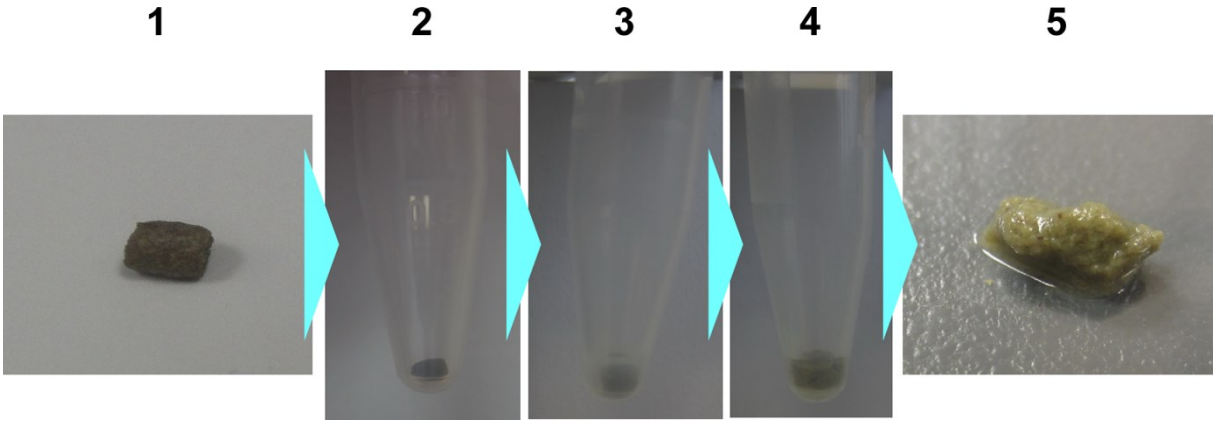

Fig. SI5: CeO_2 NP exposure preparation: A dry food pellet (1) was placed into an Eppendorf tube (2). 50 µL of a [Ce-139/Ce-141]CeO_2 NP dispersion in 5 ppm aqueous fulvic acid was added (3). Within 10 min the food pellet soaked up almost all the provided dispersion (4). The food pellet was removed and excess dispersion was removed by placing the pellet on a glass slide (5) before adding it to the uptake experiment container. This way about 75 % of the CeO_2 in the original dispersion remained heavily infiltrated in the pellet, which kept its structural integrity during the process. Additionally, a control experiment was performed by placing a [Ce-139/Ce-141]CeO_2 food pellet prepared as described above into an experimental vessel with 10 mL of moderately hard standard water (CeO_2 ζ-pot. = 15.8 ± 1.2 mV). This was placed on the horizontal shaker to simulate the conditions during the uptake experiment. After 16 h the vessel was left to stand for 15 min and 5 mL of the supernatant was removed for activity measurement. This showed that > 90% of the CeO_2 NP remained agglomerated and sedimented with the rest of the food pellet. As CeO_2 could also be taken up by the shrimp from the water our offered dose of 59 µg CeO_2/shrimp refers to the full 100% of CeO_2 that was added to the uptake experiment.

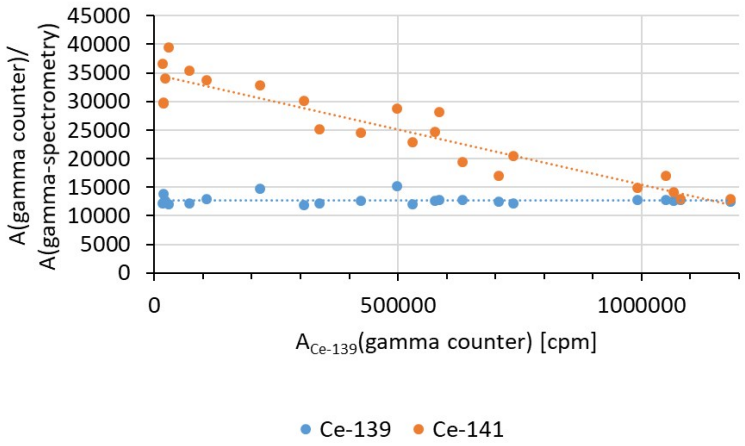

Fig. SI6: Calibration factors for transformation of gamma-counter activity measurements in activity according to gamma spectrometry data. Overspill of Ce-139 into Ce-141 window was corrected according to measured Ce-139 activity.

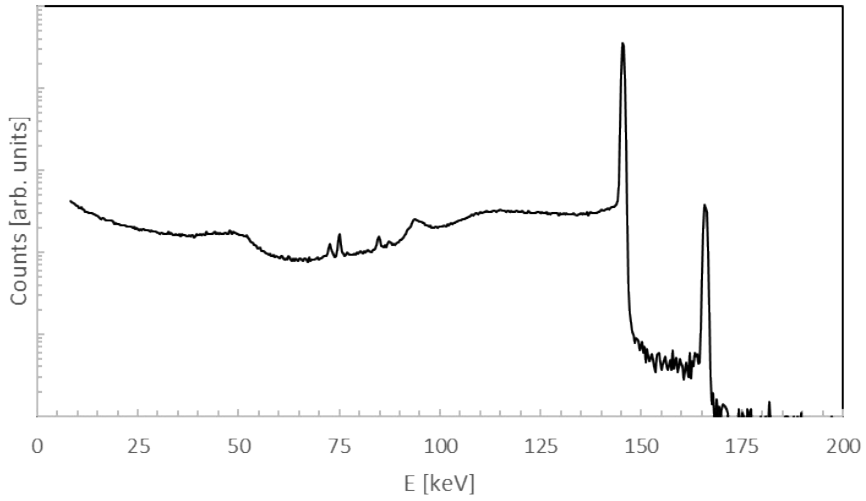

Fig. SI7: Gamma spectrum of activated [Ce-141]CeO_2 NPs after decay period.

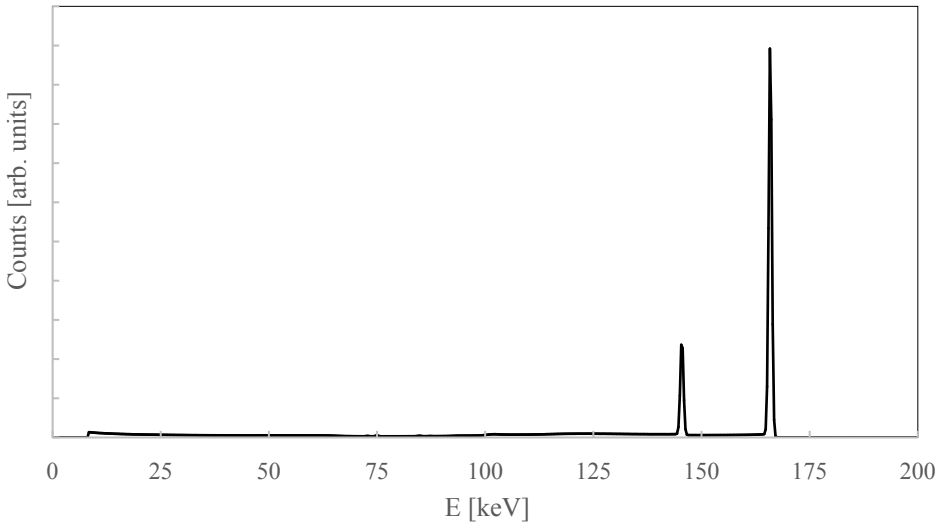

Fig. SI8: Gamma spectrum of activated and in-diffusion-labelled [Ce-139/Ce-141]CeO_2.

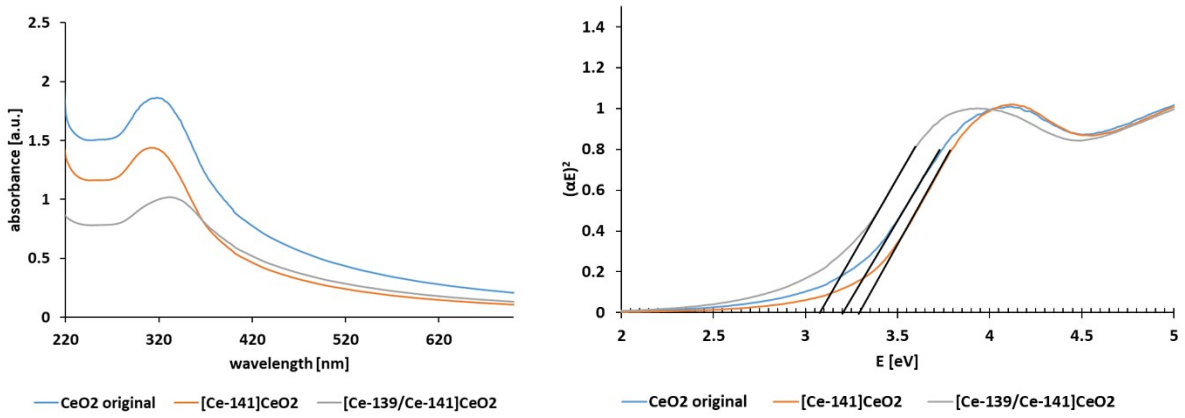

Fig. SI9: (left) UV/Vis spectra of CeO_2 NPs, (right) Tauc plot of UV/Vis data for bandgap evaluation.

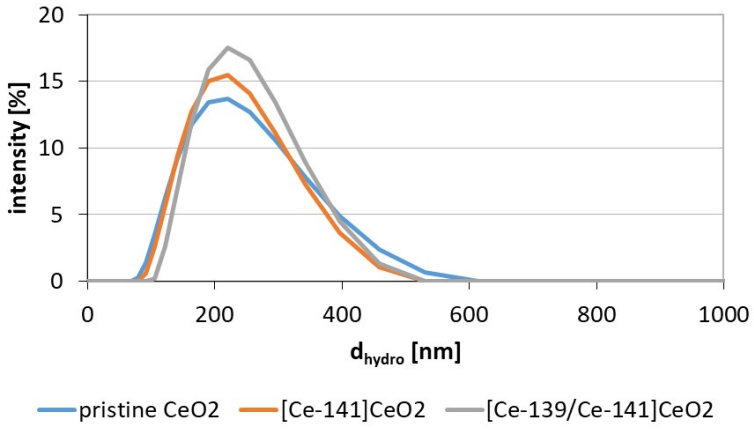

Fig. SI10: DLS size distributions of labelled CeO_2 NPs.

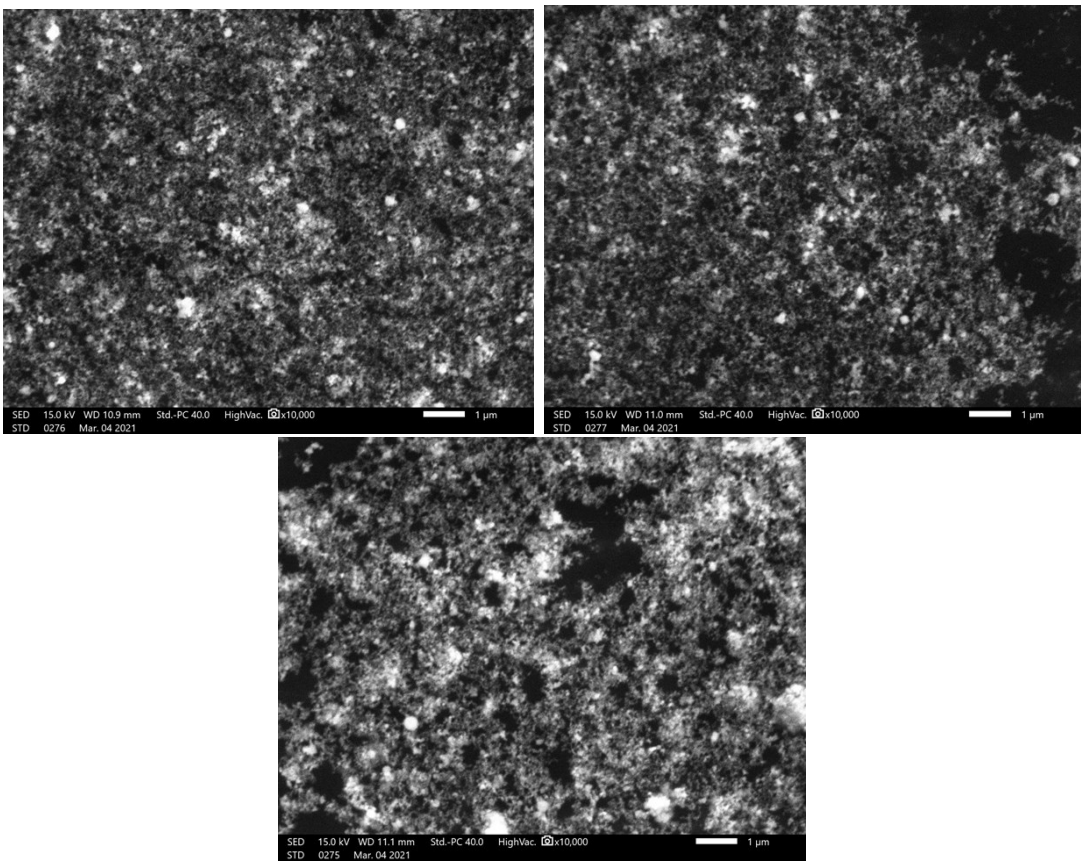

Fig. SI11: SEM images of CeO_2 NPs, (top left) pristine CeO_2 NPs, (top right) [Ce-141]CeO_2 and (bottom) [Ce-139/Ce-141]CeO_2 NPs.

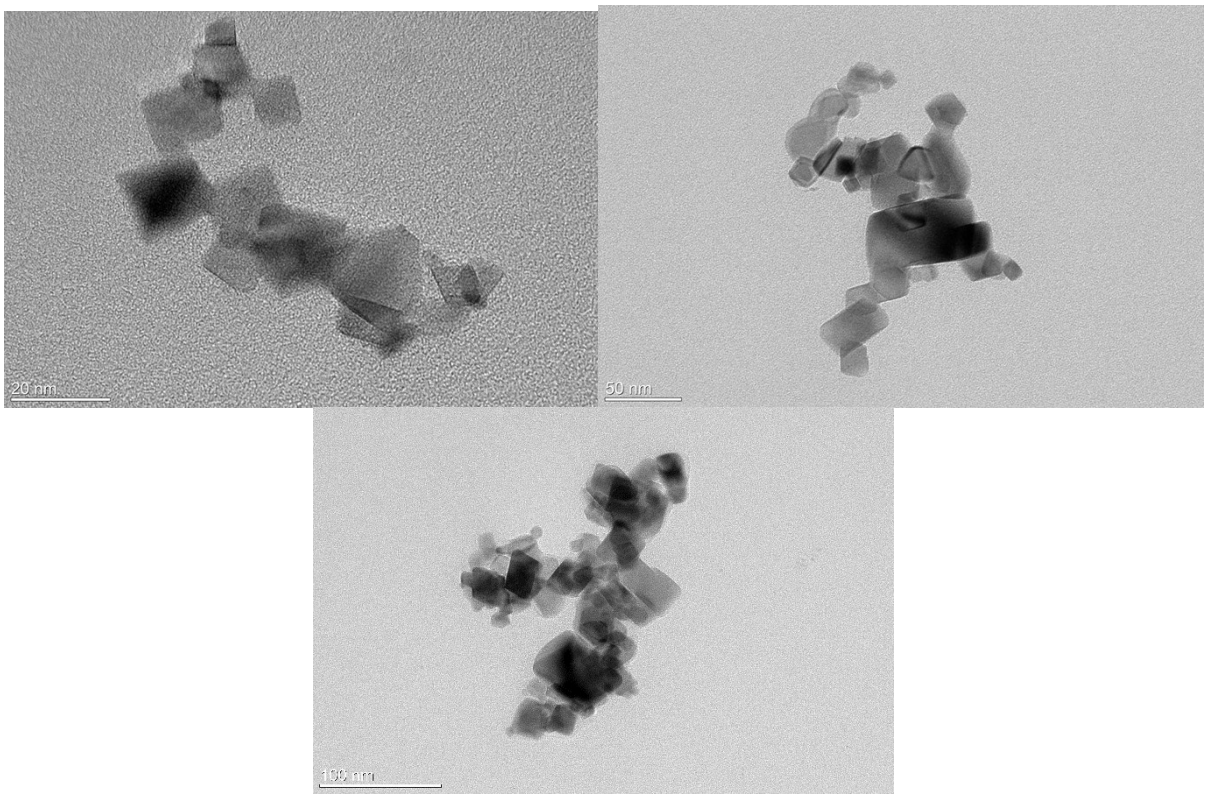

Fig. SI12: TEM images of CeO_2 NPs, (top left) pristine CeO_2 NPs, (top right) [Ce-141]CeO_2 and (bottom) [Ce-139/Ce-141]CeO_2 NPs.

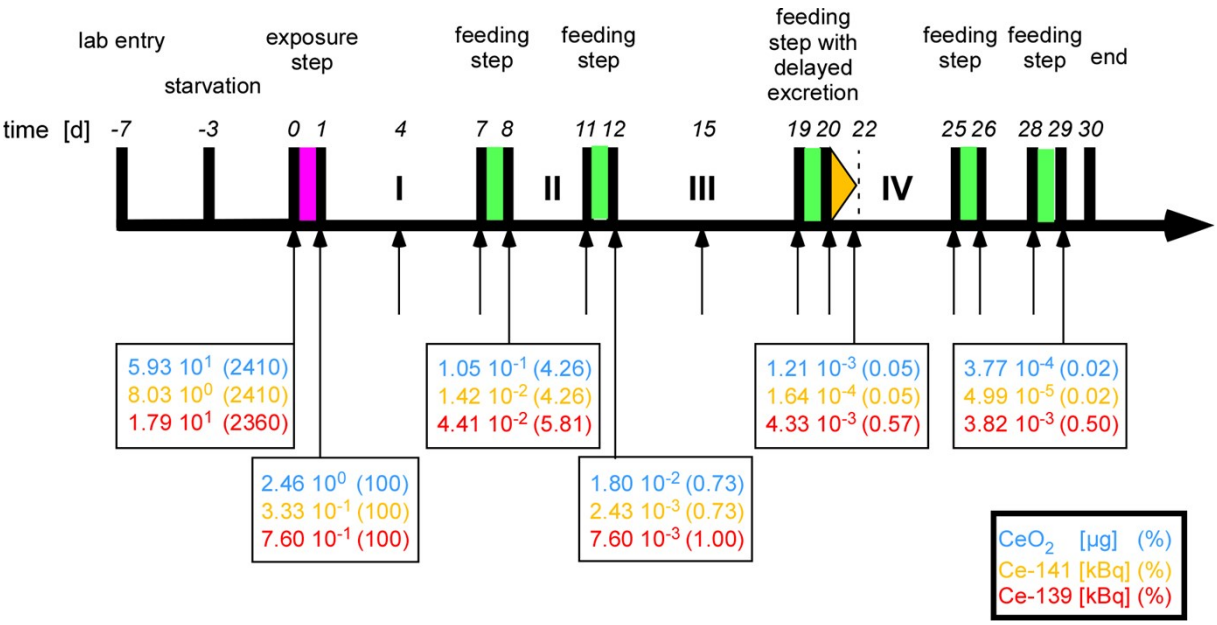

Fig. SI13: Experimental design of CeO_2 NP uptake experiment from lab entry to the end of the experimental run and development of the CeO_2 content and Ce-radionuclide activities per shrimp over four excretion periods (I-IV). The day of exposure is set as the zero point and the amount of Ce activity after the exposure step at day 1 is set as 100 %. The overnight exposure step with CeO_2 NP is indicated in pink, any subsequent feeding steps without CeO_2 are indicated in green. One moulting related delayed excretion is indicated in orange. Arrows indicate any activity measurements taken. For selected measurements the CeO_2 content, Ce-141 activity, and Ce-139 activity per shrimp are given.

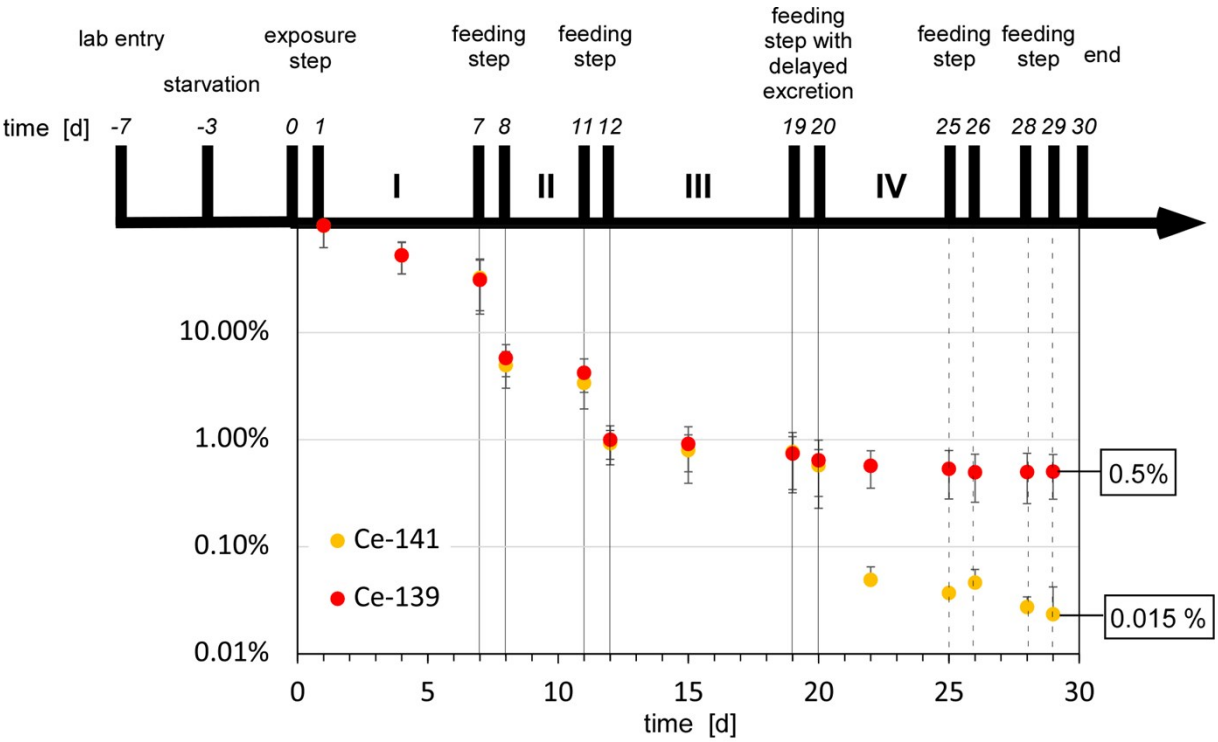

Fig. SI14: Experimental design of CeO_2 NP uptake experiment from lab entry to the end of the experimental run and development of the Ce-radionuclide activities inside the shrimps over four excretion periods (I-IV). The day of exposure is set as the zero point and the amount of Ce activity after the exposure step at day 1 is set as 100 %.

Tab. SI1: Elemental analysis of fulvic acid

element	wt%
C	53.0
H	4.3
N	0.6
S	0.6
O	41.5

Tab. SI2: Acidity of fulvic acid

acidity	meq/g
total acidity	8.1
COOH groups	5.5
phenolic OH groups	2.6