Electronic Supplementary Material (ESI) for Environmental Science: Nano.

Supplementary information

Ecotoxicity testing of nanomaterials in sediment – suggestions to improve science and regulation of NMs

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Table 1, SI

ECHA and OECD Recommendation	1. Choice of test sediment	2. Method of spiking	3. Homogenization of spiked sediment		4. Exposure concentration (at beginning and end of exposure and potentially at water exchange)			5. Storage, aging, and equilibrium time (incl. transformations such as dissolution)				
Reference	1. Use Standardized test sediment (ECHA and OECD)	2. Direct wet addition of NMs (ECHA and OECD)	3.1 Homogenize spiked sediment (ECHA and OECD)	3.2 Confirm homogenization analytically (OECD)	4.1 Determine bulk concentration in sediment (ECHA and OECD)	4.2 Determine concentration in overlying water (ECHA and OECD)	4.3 Determine concentration in porewater (ECHA and OECD)	5. Apply equilibration time (ECHA and OECD)	5.1 Dissolution measured or discussed (ECHA and OECD)	NM Characteristics	Reference compounds used	Notes
	Standard sediment used	Spiking method	Homogenization conducted	Homogenization confirmed a) aliquots from 3 places after spiking b) Concentration reported as mean + SD c) below 20 variability is desirable d) method of collection reported e) analytical method reported	Concentrations determined at a) start b) end c) water exchange d) method of collection reported e) analytical method reported			Sediment spiked and stored > 48 h	a) information on dissolution b) discussion on implications	Primary particle size # a) according to manu-facturer b) measured c) further characterization conducted		

Lammel/Thit et al., 2019	no	yes	yes, by hand and subsequently, 48h on shaking table	a) no, exposure sediment t end (n=6) but not stock	a) no b) yes c) NA d) yes e) yes	a) no b) no c) no	a) no b) no c) no	Partly. yes- during homogenization	a) yes, literature. b) Partly	CuO NPs: < a) 50 nm b) 51.9 x 79.1 nm c) yes	$CuCl_2 \cdot 2H_2O$	
Nielsen et al., 2022	no	yes	yes, 24h	a) no	a) yes b) no c) NA d) yes e) yes	a) no b) no c) NA	a) no b) no c) NA	No, only 24h during homogenization	a) no b) no	Ag NPs a) NR b) 74.1 nm c) yes	$AgNO_3$	
Little et al., 2021	yes, with minor adjustments.	Ag: yes, with stabilizer. TiO_2 as powder Partly (not fully reported).	yes, overnight	a) no	no	no	no	yes, for 48h in test container	a) Partly, (not measured) b) yes	Ag; NM-300 K a) 15 nm b) 15.16 nm c) yes TiO_2: NM-104 a) ~20 b) 159.06 nm c) yes	$AgNO_3$	Two different NPs tested
Thit et al., 2016	no	Suspended NMs added to sediment (wet)	20 min by hand, 2h shaking table, settle over night	a) no	a) yes b) yes c) yes d) no e) yes	no	a) yes b) yes c) no	Settle in test containers overnight	a) Literature b) yes	^{65}CuO NP a) 7 nm b) 7 nm* c) yes*	$^{65}Cu(NO_3)_2$	Isotopically labelled NPs used
Ramskov et al., 2015b	no	Suspended NMs added to sediment (wet)	Not specified	a) no	a) yes b) yes c) yes d) no e) yes	no	a) yes b) yes c) no	Settle in test containers overnight	a) Literature b) yes	^{65}CuO NP* a) 7 nm b) 7 nm c) yes	$^{65}Cu(NO_3)_2$	Isotopically labelled NPs used
Thit et al., 2015a	no	Suspended NMs	10 min by hand,	a) no	a) no b) yes	no	no	Not specified	a) Literature b) yes	CuO NP spheres*	$CuCl_2 \cdot 2H_2O$	Three shapes

		added to sediment (wet)	shaking table over night		c) no d) yes e) yes					a) 6 nm b) 6 nm c) yes CuO NP rods* a) 10x36 nm b) 10x36 nm c) yes CuO NP spindles* a) 20x100 nm b) 20x100 nm c) yes		and sizes of NPs used
Thit et al., 2015b	no	Suspended NMs added to sediment (wet)	mixed by hand, shaking table over night	a) no b) Quantified in sediment after homogenization and at beginning of experiment c) yes d) yes e) yes	a) yes b) no c) no d) no e) yes	no	no	Settle in the test containers overnight	a) Comparison to Cu aq in the exposure	CuO NP a) 100 nm b) <100 nm c) yes	$CuCl_2$ and bulk CuO (Micro < 5µm)	
García-Alonso et al., 2011	no	Suspended NMs added to sediment (wet and dry)	Mixed with spatula, left for 24h	a) no	no	no	no	24h in test containers	a) No	Ag NP* (Citrate capped) a) 30 nm b) 30 nm c) yes	$AgNO_3$	Only nominal concentrations used, no quantification of dissolved content, but compared to aqueous exposure

Dai et al., 2015	no	Suspended NMs added to sediment (wet)	shaking table 24h	a) no	a) yes b) no c) no d) no e) yes	no	no	Not specified	a) Comparison to Cu_aq in the exposure b) literature	CuO NP spheres* a) 7 nm b) 7 nm c) yes CuO NP rods* a) 7x40 nm b) 7x40 nm c) yes CuO NP platelets* a) 270x1140 nm b) 270x1140 nm c) yes CuO nanopowder a) <100 nm b) NR c) yes	$CuCl_2$ and bulk CuO (Micro < 5µm)	CuO NPs of different sizes and shapes were used
Stanley et al., 2010	no	Not specified	Rotary shaker 1h	a) no	a) yes b) no c) no d) no e) yes	no	no	Not specified	a) Dialysis b) yes	Nano-Al_2O_3 a) 11 nm b) 11 - >100 nm c) yes	Micron-sized Al_2O_3 (50-200 µm)	
Galloway et al., 2010.	no	Suspended NMs added to sediment (wet)	Mixed by hand 15 min	a) no	no	no	no	24h prior to test start	No	Nano-TiO_2 a) NR b) 32.4 nm c) yes		Different NMs tested (Carbon Nanotubes), No information on dissolution or actual concentrations, only

												reported nominal
Fabrega et al., 2012	no	Suspended NMs added to sediment (wet)	Not specified	a) no	no	no	no	Not specified	a) Dialysis b) yes	ZnO NPs a) NR b) 35 nm c) yes	$ZnCl_2$ and Bulk ZnO (160 nm)	Only nominal concentrations used, no quantification during exposure.
Cong et al., 2011	no	Suspended NMs added to sediment (wet) and mixed with exposure sediment	Not specified	no	a) yes b) no c) no d) no e) yes	no	no	Not specified	a) Comparison to Ag_aq in the exposure b) literature	Ag NP Powder a) <100 nm b) 20-200 nm c) yes	AgNO3) and Micron-Ag (2–3.5µm)	
Cong et al., 2014	no	Suspended NMs added to sediment (wet) and mixed with exposure sediment	Not specified	no	a) yes b) no c) no d) no e) yes	no	no	Not specified	a) Comparison to Agaq in the exposure b) literatur	Ag NP 20nm a) 20 nm b) ~ 50 nm c) yes Ag NP 80nm a) 80nm b) ~ 50nm (2-100 nm) c) yes	$AgNO_3$	Two sizes of NPs were tested
Dai et al., 2013	no	Not specified	Not specified	no	a) yes b) no c) no d) no e) yes	no	no	No	a) Comparison to Ag-aq and Cu-aq in the exposure	Ag NP 20nm a) 20 nm b) c) no Ag NP 80nm a) 80nm b) no c) no CuO NP powder <100	$AgNO_3$, Micron Ag, $CuCl_2$·2H2O and Micron CuO (<5µm)	NPs of different metals and sizes were tested

										nm a) <100 b) no c) no		
Ramskov et al., 2015a	no	Suspended NMs added to sediment (wet)	Mixed by hand, shaking table overnight	no	a) yes b) no c) no d) no e) yes	no	yes	no	a) Comparison to Ag_aq in the exposure b) literature	Ag NP * a) 10-15 nm b) nm 13nm (DLS) c) yes	$AgNO_3$	
Lammel/Thit et al., 2020	no	Suspended NMs added to sediment (wet)	Mixed by hand, shaking table overnight	a) yes b) yes c) yes d) yes e) yes	a) yes	yes	a) yes b) yes c) yes	no	a) Comparison to Cu_aq in the exposure	^{65}CuO NPs* a) ~20 nm b) ~20 nm c) yes, published in other study	^{65}CuCl2	Isotopically labelled NPs used
Fan et al., 2018	no	Powder directly added to sediment	Mixed by steel blender 24h at 60 rpm	no	no	no	no	no	no	TiO_2 powder a) 5–10 nm b) no c) no		The TiO_2 exposure concentration was not quantified, only the bioavailability of the heavy metals was quantified.
Pang et al., 2012	no	yes	yes, 24h	a) spiking efficiency measured but not reported	a) yes b)yes c) no (sediment was	no	no	No, but 24h homogenization times 2	a) no b) no	CuO NP* a) 6 nm b) 6 nm c) yes	CuCl2 and micro-CuO (<5 µm)	Sediment was changed weekly.

					changed) d) no e) yes								
Pang et al., 2013	no	yes	yes, 24h on shaking table		a) yes b) yes c) no d) no e) yes	no	a) no b) yes c) NR	no	a) no b) no	CuO NP* a) 6 nm b) 6 nm c) yes	$CuCl_2$ and micro-CuO (<5 µm)		
Ramskov et al., 2014	no	yes	yes, overnight on shaking table	a) partly spiking efficiency. b) no c) NA d) no e) yes	a) yes b) partly (in study 1 yes, 2 no) c) no d) no e) yes	no	a) yes, in one of two studies study b) yes in one of 2 studies	no, but equilibratio n time in beaker for 24h	a) no b) yes	CuO NP spheres* a) no b) 7 nm c) yes CuO NP rods* a) no b) 8x40 nm c) yes CuO NP platelets* a) no b) 270x1140 nm c) yes	$CuCl_2$	Contain 2 studies.	
Buffet et al., 2014	no	Partly, yes: suspensio n added to water surface (indirect addition)	no	NR	no	no	no	no	a) yes b) yes	Ag NPs* a) 40-45 nm b) 40-45 nm determined with DLS. c) yes	$AgNO_3$		
Hanna et al., 2013	no	Partly. Direct addition into sediment.	yes, but only 1 min stirring	no	a) no b) yes c) no/NR d) yes e) yes	a) no b) yes c) no/NR	a) no b) yes c) no/NR	no	a) yes b) yes	ZnO ENPs ZnO ENPs a) 20-30 nm b) published		Three metal NMs tested	

		unclear, but seems to be added as powder								previously c) yes CuO a) 200-1000nm b) no c) yes NiO ENPs a) 13.1 nm b) no c) yes		
Buffet et al., 2012	no	indirect addition of suspension into overlaying water and distribution in sediment thoroughly characterized.	no/NR	no/NR	a) yes b) yes c) no/NR d) yes e) yes 3 cores collected and metal distribution in sediment determined	no	no	no/NR	a) no, measured previously b) very briefly	^{67}ZnO NPs* a) 20-30 nm b) 20-30 nm c) yes		Isotopically labelled NPs used
Buffet et al., 2013	no	Indirect addition of suspension into overlaying water and distribution in sediment thoroughly characterized.	no/nr	no /NR	no	no, only labile Cu measured with DGT	no, only labile Cu measured with DGT	No, only labile Cu measured with DGT	a) yes in overlaying water and sediment porewater with DGT b) yes	Ag NP a) 40-45 nm b) NR c) yes	Soluble Ag	

Thit et al., 2021a	no	yes	yes for 72 hs on shaking table	a) no b) yes c)NR d)no e) yes	a) partly: in one experiment t0 sed conc was measured in other only spiked sediment but not t 0 sediment measured. b) yes c) NR d) no e) yes	no	a) no b) yes c) NR	homogenized for 72 hs, and in one experiment aged for 2 years	a) no b) yes	CuO NP* a) 20 nm b) 20 nm c) yes, published previously	$CuCl_2$	Isotopically labelled NPs used. Two experiments, fresh and aged for 2 years not distinguished properly between t0 and spike sediment.
Thit and Selck, 2021b	no	yes	yes, 48h	no	a) exposure concentrations are measured, but method not reported, likely start concentration b)? likely not c) NR d) no e) yes	no	no	48 during homogenization-	a) no b) yes	^{65}CuO NPs* a) 7 nm b) 7 nm c) yes	$^{65}CuCl_2$	Isotopically labelled NPs used
Luo et al., 2021	no	yes	yes, shaking table overnight	no	a) no but day 1. b) no c)no/NR d) yes	no	a) no but day 1. b) no c) no/NR d) yes	overnight during homogenization and subsequent	a) no, but in previous publication. b) partly. limited	AuENP MUDA5* a) 5nm b) Previously reported	Au^{3+}	Different sizes and coatings were used.

					e) yes		e) yes	settling for 24 h	discussion but Au salt used as reference.	c) yes AuENP MUDA30* a) 5nm b) Previously reported c) yes AuENP CIT5* a) 5nm b) Previously reported C) yes AuENP CIT30* a) 5nm b) Previosly reported C) yes AuENP BSA* a) 5nm b) Previously reported c) yes		characterized sediment grain size fractions such as clay, silt and sand.
Scola et al., 2021	no	yes	yes, by thorough mixing for 2 weeks.	no a) no b)	a) yes b) yes c) no, but throughout experiment d) no e) yes	a) yes b) yes c) no, but throughout experiment	a) yes b) yes c) no, but throughout experiment	partly as it was mixed/homogenized for 2 weeks after spiking	salt used as reference	CuO NPs a) <50 nm b) no c) yes	$CuCl_2$	
Oberholster et al., 2011	partly: artificial sediment	directly mixed in sediment	yes, thoroughly mixed by hand. time not stated	no	no	no	no	no	no	Fe_2O_3* a) 50-150nm b) 50-150nm c) yes SiO_2* a) 100-400nm		Seven different types of NMs used

										b) 100-400nm c) yes Calcinated SiO_2* a) 50-300nm b) 50-300nm c) yes Precipitated SiO_2* a) 20-100nm b) 20-100nm c) yes Sb_2O_5* a) 5000-15000nm b) 5000-15000nm c) yes α-Alumina* a) 20-50nm b) 20-50nm c) yes γ-Alumina* a) 80-4000nm b) 80-4000nm c) yes All determined via DLS		
Carley et al., 2020	no	no	no	no	End: Day 269	no	yes: Weekly or monthly	no	no	Kocide 300 containing $Cu(OH)_2$ a) NR b) 38.7nm C) yes		A nanopesticide containing NPs, microparticles and nanosheets. Outdoor

												mesocosm eukaryotes and their roles in sediment and soil function
Huang et al., 2019	yes, C. elegans sediment exposure was conducted according to standardized methods	yes	yes, through stirring for 2 min.	no	End after 96 h using ICP-AES	End after 96 h using ICP-AES	End	yes, equilibrated and air-dried at room temperature for 2 weeks	no	ZnO_2 a) <50nm b) images reported, but not size c) yes	$ZnCl_2$	
Bao et al., 2018	no	yes	???	no	yes: Start and end of experiment	yes: Start and end of experiment	yes: Start and end of experiment	yes, 72 h	Ag from the sediment was lost to the overlaying water. Exact state of AgNMs in sediment not determined	AgNPs-20 a) 20nm b) 18.0nm c) yes AgNPs-40nm a) 40m b) 30.2nm c) yes AgNPs-80 a) 80nm b) 57.0nm c) yes	$AgNO_3$ And Bulk Ag (10 µm)	NPs of different sizes where used
Parks, et al., 2018	No, not artificial standard OECD sediment, but Long Island Sound (USA)	yes	yes, mixed for 3 min.	no	yes, start using ICP-AES	No	No	yes, for 12 days	No, end concentration and ionic form not measured	Kocide $CuOH_2$ a) NR b) no c) no CuPRO, $CuOH_2$ a) NR b) no	$CuSO_4$, $CuCO_3$, Alkaline Cu quaternary (CuO),	a range of products containing nano Cu and constituents were used

	reference sediment, which is field collected sediment. sediment collected from the field.									c) no Micronized Cu azole a) no b) 10-700 nm previously reported c) no		
Rajala et al., 2018.	yes, OECD Test No. 225	yes	Mixed and then rotated for 48 h in overhead mixer	no	yes, start and end of experiment (23 d) using ICP-OES			yes, for 14 days	Literature. Salt used as reference	uncoated AgNP, a) 35nm b) 39.4nm c) yes PVP-coated Ag NPs a) 30-50nm b) 28.6nm nm c) yes	$AgNO_3$	NPs with different coatings were used
Fan et al., 2017	no	no	Mixed for 24 h	no	End: Approximately 2.0 cm below the sediment surface with a Rhizon sampler and ICP-MS and SEM	no	End: Approximately 2.0 cm above the sediment surface with injectors and filtration and ICP-MS and SEM	yes, for 60 days	Aggregation discussion with reference to literature	TiO2 a) 5-10nm b) larger than stated by manufacturer measured by SEM c) yes		
Ma et al., 2017	no	no	Mixed for 1 h	no	yes: Start, end and weekly sediment	yes: Start, end and weekly sediment	no	yes, for 14 days	Indications that CuO-MPs and NMs may	CuO NP a) 40nm b) 41.6nm with SEM	$CuSO_4$ and Micro (10µm)	

					renewal using ICP-OES	renewal using ICP-OES			have remarkable low solubility within sediments	c) yes		
Lee et al., 2016	no	yes	Not clear since it is stated that “a modified EPA method was used for sampling, mixing and homogenization” we assume	no	yes a) yes after 0.5 h b) yes 7 d c) NR, but samples collected at several timepoints d)no e) yes	no	yes	no, not stated	a) yes in water. b) yes	AgNPs a) <100nm b) nm c) yes		To mimic field condition more accurately
Rajala et al., 2016	yes (OECD 225) and field collected sediment to compare	No direct addition of dry powder	Rotating metal blade for 1 h		a) no b) no c) no/NR collection time not reported. d) no e) yes	no	no	2 or 7 days in beakers before exposure initiation	a) no, metal ion used as reference b) yes	AgNP a) 30-50 b) 82nm published previously c) published previously	$AgNO_3$	Artificial sediment compared to two field collected sediments.

Table 1, SI. Summary of main findings from analysis of selected papers on sediment ecotoxicity of metal NPs in benthic organisms.

NR: not reported.

* Nanoparticles are produced and characterized for the specific study and thus characterization data from manufacturer is the same as from the study.

Primary particle size determined with TEM, unless otherwise stated.

Literature analyzed:

1. Lammel, T./Thit, A., Mouneyrac, C., Baun, A., Sturve, J., Selck, H. Trophic transfer of CuO NPs and dissolved Cu from sediment to worms to fish-a proof-of-concept study (2019) Environmental Science: Nano, 6 (4), pp. 1140-1155. DOI: 10.1039/c9en00093c

2. Little, S., Johnston, H.J., Stone, V., Fernandes, T.F. Acute waterborne and chronic sediment toxicity of silver and titanium dioxide nanomaterials towards the oligochaete, Lumbriculus variegatus (2021) NanoImpact, 21, art. no. 100291. DOI: 10.1016/j.impact.2020.100291

3. Nielsen, M.B., Vavra, J., Palmqvist, A., Forbes, V.E. Long-term effects of sediment-associated silver nanoparticles and silver nitrate on the deposit-feeding polychaete Capitella teleta (2022) Aquatic Toxicology, 242, art. no. 106046. DOI: 10.1016/j.aquatox.2021.106046

4. Thit, A., Ramskov, T., Croteau, M.-N., Selck, H. Biodynamics of copper oxide nanoparticles and copper ions in an oligochaete - Part II: Subcellular distribution following sediment exposure (2016) Aquatic Toxicology, 180, pp. 25-35. DOI: 10.1016/j.aquatox.2016.08.011

5. Ramskov, T., Thit, A., Croteau, M.-N., Selck, H. Biodynamics of copper oxide nanoparticles and copper ions in an oligochaete - Part I: Relative importance of water and sediment as exposure routes (2015b) Aquatic Toxicology, 164, pp. 81-91. DOI: 10.1016/j.aquatox.2015.04.022

6. Thit, A., Dybowska, A., Købler, C., Kennaway, G., Selck, H. Influence of copper oxide nanoparticle shape on bioaccumulation, cellular internalization and effects in the estuarine sediment-dwelling polychaete, Nereis diversicolor (2015a) Marine Environmental Research, 111, pp. 89-98. DOI: 10.1016/j.marenvres.2015.06.009

7. Thit, A., Banta, G.T., Selck, H. Bioaccumulation, subcellular distribution and toxicity of sediment-associated copper in the ragworm Nereis diversicolor: The relative importance of aqueous copper, copper oxide nanoparticles and microparticles (2015b) Environmental Pollution, 202, pp. 50-57. DOI: 10.1016/j.envpol.2015.02.025

8. García-Alonso, J., Khan, F.R., Misra, S.K., Turmaine, M., Smith, B.D., Rainbow, P.S., Luoma, S.N., Valsami-Jones, E. Cellular internalization of silver nanoparticles in gut epithelia of the estuarine polychaete nereis diversicolor (2011) Environmental Science and Technology, 45 (10), pp. 4630-4636. DOI: 10.1021/es2005122

9. Dai, L., Banta, G.T., Selck, H., Forbes, V.E. Influence of copper oxide nanoparticle form and shape on toxicity and bioaccumulation in the deposit feeder, Capitella teleta (2015) Marine Environmental Research, 111, pp. 99-106. DOI: 10.1016/j.marenvres.2015.06.010

10. Stanley, J.K., Coleman, J.G., Weiss Jr., C.A., Steevens, J.A. Sediment toxicity and bioaccumulation of nano and micron-sized aluminum oxide (2010) Environmental Toxicology and Chemistry, 29 (2), pp. 422-429. DOI: 10.1002/etc.52

11. Galloway, T., Lewis, C., Dolciotti, I., Johnston, B.D., Moger, J., Regoli, F. Sublethal toxicity of nano-titanium dioxide and carbon nanotubes in a sediment dwelling marine polychaete (2010) Environmental Pollution, 158 (5), pp. 1748-1755. DOI: 10.1016/j.envpol.2009.11.013

12. Fabrega, J., Tantra, R., Amer, A., Stolpe, B., Tomkins, J., Fry, T., Lead, J.R., Tyler, C.R., Galloway, T.S. Sequestration of zinc from zinc oxide nanoparticles and life cycle effects in the sediment dweller amphipod corophium volutator (2012) Environmental Science and Technology, 46 (2), pp. 1128-1135. DOI: 10.1021/es202570g

13. Cong, Y., Banta, G.T., Selck, H., Berhanu, D., Valsami-Jones, E., Forbes, V.E. Toxic effects and bioaccumulation of nano-, micron- and ionic-Ag in the polychaete, Nereis diversicolor (2011) Aquatic Toxicology, 105 (3-4), pp. 403-411. DOI: 10.1016/j.aquatox.2011.07.014

14. Cong, Y., Banta, G.T., Selck, H., Berhanu, D., Valsami-Jones, E., Forbes, V.E. Toxicity and bioaccumulation of sediment-associated silver nanoparticles in the estuarine polychaete, Nereis (Hediste) diversicolor (2014) Aquatic Toxicology, 156, pp. 106-115. DOI: 10.1016/j.aquatox.2014.08.001

15. Dai, L., Syberg, K., Banta, G.T., Selck, H., Forbes, V.E. Effects, uptake, and depuration kinetics of silver oxide and copper oxide nanoparticles in a marine deposit feeder, macoma balthica (2013) ACS Sustainable Chemistry and Engineering, 1 (7), pp. 760-767. DOI: 10.1021/sc4000434

16. Ramskov, T., Forbes, V.E., Gilliland, D., Selck, H. Accumulation and effects of sediment-associated silver nanoparticles to sediment-dwelling invertebrates (2015a) Aquatic Toxicology, 166, pp. 96-105. DOI: 10.1016/j.aquatox.2015.07.002

17. Lammel, T./Thit, A., Cui, X., Mouneyrac, C., Baun, A., Valsami-Jones, E., Sturve, J., Selck, H. Trophic transfer of CuO NPs from sediment to worms (: Tubifex tubifex) to fish (Gasterosteus aculeatus): a comparative study of dissolved Cu and NPs enriched with a stable isotope tracer (65Cu) (2020) Environmental Science: Nano, 7 (8), pp. 2360-2372. DOI: 10.1039/d0en00227e

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20. Pang, C., Selck, H., Misra, S.K., Berhanu, D., Dybowska, A., Valsami-Jones, E., Forbes, V.E. Effects of sediment-associated copper to the deposit-feeding snail, Potamopyrgus antipodarum: A comparison of Cu added in aqueous form or as nano- and micro-CuO particles (2012) Aquatic Toxicology, 106-107, pp. 114-122. DOI: 10.1016/j.aquatox.2011.10.005

21. Pang, C., Selck, H., Banta, G.T., Misra, S.K., Berhanu, D., Dybowska, A., Valsami-Jones, E., Forbes, V.E. Bioaccumulation, toxicokinetics, and effects of copper from sediment spiked with aqueous Cu, nano-CuO, or micro-CuO in the deposit-feeding snail, Potamopyrgus antipodarum (2013) Environmental Toxicology and Chemistry, 32 (7), pp. 1561-1573. DOI: 10.1002/etc.2216

22. Ramskov, T., Selck, H., Banta, G., Misra, S.K., Berhanu, D., Valsami-Jones, E., Forbes, V.E. Bioaccumulation and effects of different-shaped copper oxide nanoparticles in the deposit-feeding snail Potamopyrgus antipodarum (2014) Environmental Toxicology and Chemistry, 33 (9), pp. 1976-1987. DOI: 10.1002/etc.2639

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