



Miljøministeriet
Miljøstyrelsen

Annex II: Nanomaterials in the Danish Environment

Modelling exposure of the Danish
environment to selected
nanomaterials

Annex II for environmental project No.
1639, 2015

Title:

Annex II:
Environmental Exposure to Nanomaterials
in Denmark.

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Published by:

The Danish Environmental Protection Agency
Strandgade 29
1401 Copenhagen K
Denmark
www.mst.dk/english

Year:

2015

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1. Introduction

This Annex II shows the model architecture (Chapter 2) and provides all the modelled results (Chapter 3) that belong to the main report. However, this Annex II limits itself by presenting results and does not give any text-based guide for the reader for interpreting or evaluating the content. For that kind of information the reader may consult the corresponding main report (Report 2) and its first annex (Annex I). The latter contains an overview on the model parameters used. In the main report the used methodology and the modelled results were presented and discussed.

The system geometry is shown in Chapter 1. This geometry reflects the target system "Denmark" containing the most relevant technical and environmental compartments: sewage treatment plants (STP) and waste incineration plants (WIP), compartments of material landfill and recycling processes, as well as water, sediments, air and soil environments. An insight is given also into the architecture of the subsystem "waste incineration plants".

The environmental exposure concentrations (predicted environmental concentrations (PEC) are presented for Denmark by assuming the studied engineered nanomaterial homogeneously distributed in the different compartments listed above.

The following engineered nanomaterials have been investigated:

- Silver (Ag)
- Titanium Dioxide (TiO₂) (rutile and anatase)
- Zinc Oxide (ZnO)
- Carbon Nanotubes (CNTs)
- Copper carbonate (CuCO₃)
- Zero Valent Iron (ZVI)¹
- Cerium Oxide (CeO₂)
- Carbon Black (CB)
- Quantum Dots (QDs)

Each specific section for each nanomaterial contains six Tables with modelled PEC-values for technical and natural compartments: Table 1 (of each nanomaterial specific section) provides the results of sewage treatment effluents, waste mas incinerated, bottom ash of waste mas incinerated and fly ash of waste mass incinerated. Table 2 gives the results for the terrestrial environment (agricultural soils, natural soils, urban soils and sewage treatment sludge treated soils) while tables 3 and 4 show all the PECs for the aquatic compartments covering fresh water and their sediments as well as the corresponding marine compartments (and air). Tables 5 and 6 forecast nanomaterial PECs in fresh and marine sediments as well as in the different soil types for the time period until 2014 and 2020.

¹ For this nanomaterial all the results – that mostly focus on local scenarios – are shown in the main report (Report 2).

2. System geometry

The system geometry is shown in the figures 1 and 2. Such geometry reflects the target system Denmark.

2.1 Total engineered nanomaterial mass transfer and fate system for Denmark

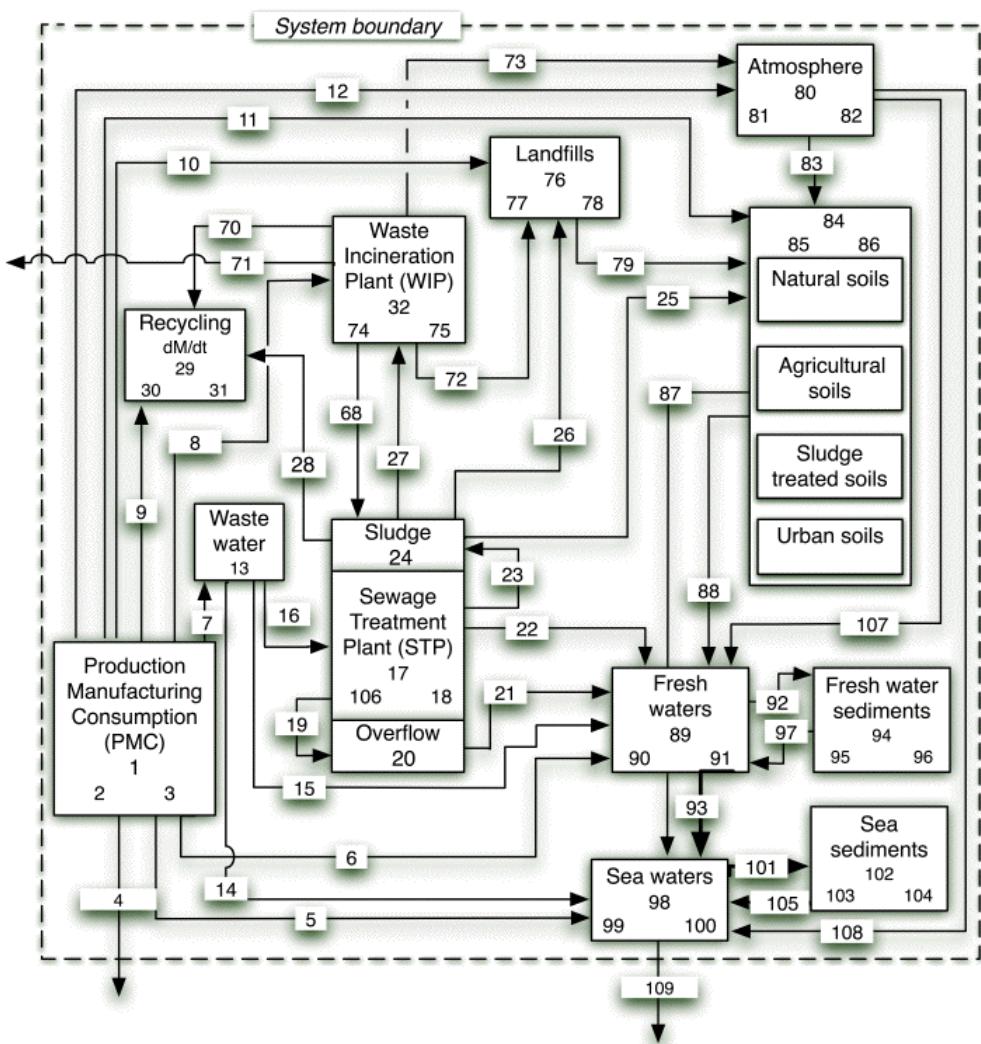


FIGURE 1. SYSTEM GEOMETRY WITH BOXES AND ENGINEERED NANOMATERIAL (ENM) FLOWS, DEPOSITION AREAS (LOWER LEFT HAND CORNER), TRANSFORMATION MASS (LOWER RIGHT HAND CORNER) AND FLOW RATES (VALUES IN THE MIDDLE OF THE BOXES AND SUB-BOXES). THE SUBSYSTEM WASTE INCINERATION PLANT (WIP) IS SHOWN IN DETAIL IN THE NEXT FIGURE (FIGURE 2). VALUES FOR ALL THESE 109 PARAMETERS FOR THE COMPUTER BASED STOCHASTIC SIMULATIONS ARE GIVEN IN ANNEX I OF THE MAIN REPORT.

2.2 Subsystem waste incineration plant

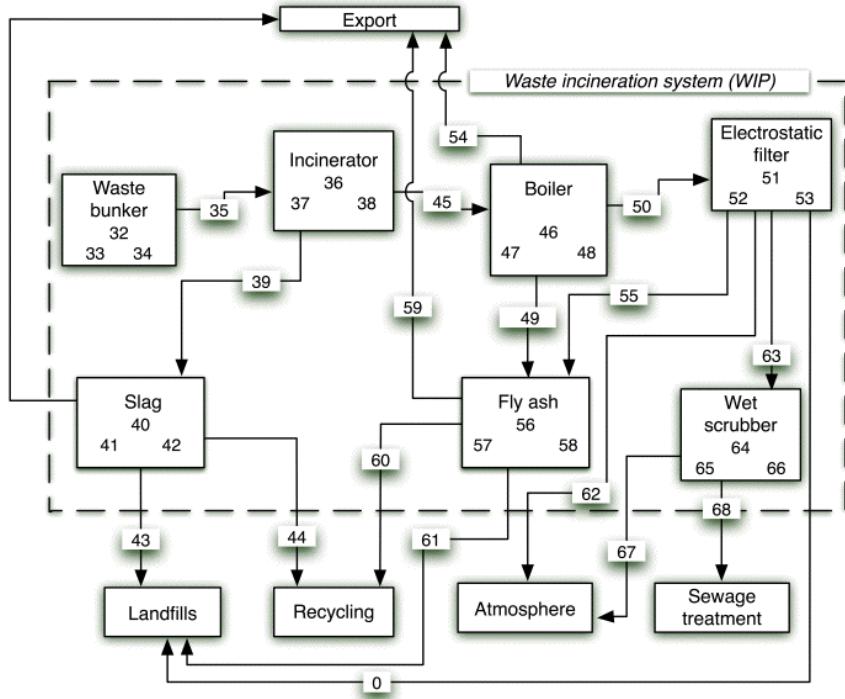


FIGURE 2.

SYSTEM GEOMETRY FOR WASTE INCINERATION PLANTS (WIP) WITH BOXES AND ENGINEERED NANOMATERIAL (ENM) FLOWS IN T/A, DEPOSITION AREAS (LOWER LEFT HAND CORNER), TRANSFORMATION MASS (LOWER RIGHT HAND CORNER) AND FLOW RATES (VALUES IN THE MIDDLE). EXEMPLARY VALUES FOR ALL THESE WIP PARAMETERS DERIVED FROM THE COMPUTER BASED STOCHASTIC SIMULATIONS ARE GIVEN FOR NANO-ZNO IN FIGURE 3.

3. Exposure concentrations in technical and natural compartments

3.1 Introduction

The Tables 1-53 summarize the predicted concentrations for a selection of engineered nanomaterials in:

- a) Residues of the main technical compartments (sewage treatment sludge, waste mass, bottom ash and fly ash of waste incineration);
- b) The main natural environments surface waters (fresh water, sea water, sewage treatment effluents), air, different soil types (agricultural, natural, urban and sludge treated soils) and sediments (fresh water and sea water sediments).

For soil and sediment results the annual concentration increase is presented given a conservative scenario of no engineered nanomaterial transformation/degradation in such compartments.

The sludge treated soil concentrations purely reflect the STP sludge contribution on such soil exposure. In order to assess the total exposure in such fertilized areas one can add the generic agricultural soil PECs to the ones of the pure sludge based contribution.

For these soil and sediment compartments we also predict concentrations after an engineered nanomaterial (ENM) deposition in soils beginning in 2000 and ending in the beginning of the year 2014 and 2020. Zero use and release and accumulation of such ENM were considered for the time before the year 2000. Since then a linear increase of ENM deposition on soils was computed by scaling the annual deposition calculated in this work for the year 2014.

We indicated in those tables the 2.5, 50 (median) and 97.5 % quantiles as well as modal values (the most frequent Monte Carlo computer simulation output).

For photostable and other nano-TiO₂ the results (probability density functions) on the annual load into different natural and technical compartments is shown (Figure 3) as an exemplary case. For nano-ZnO the results (median values) on the annual mass transfer (Figure 4) in waste incineration plants are shown as well as an exemplary case.

3.2 Photostable and other nano titanium dioxide (TiO_2)

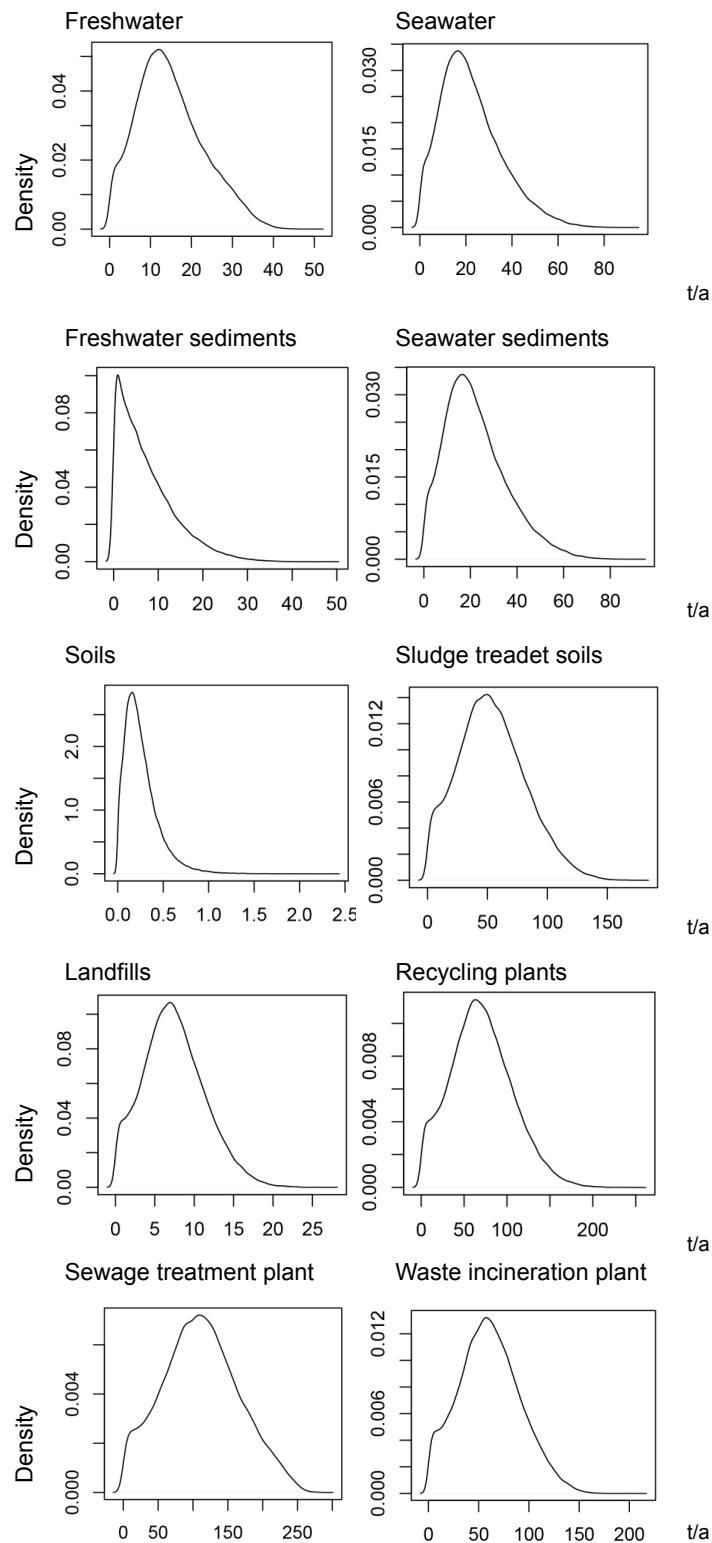


FIGURE 3.

PROBABILITY (DENSITY) DISTRIBUTIONS OF THE ANNUAL LOAD t/a OF PHOTOSTABLE AND OTHER NANO- TiO_2 INTO THE DIFFERENT NATURAL AND TECHNICAL COMPARTMENTS.

TABLES 1-6.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR PHOTOSTABLE AND OTHER NANO-TiO₂ DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Sewage treatment sludge	Min (2.5% quantile) 68.746 Mode value 774.792 Median 745.040 Max (97.5% quantile) 1477.948		mg/kg
Waste mass incinerated	1.444 14.962 15.470 32.131		mg/kg
Bottom ash of waste incineration	3.384 33.036 36.773 87.594		mg/kg
Fly ash of waste incineration	16.877 168.981 182.503 432.948		mg/kg

TABLE 2

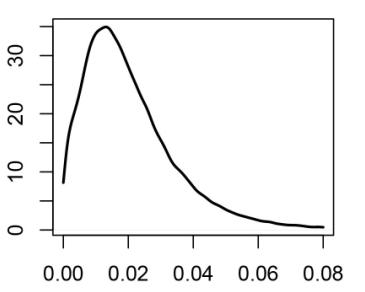
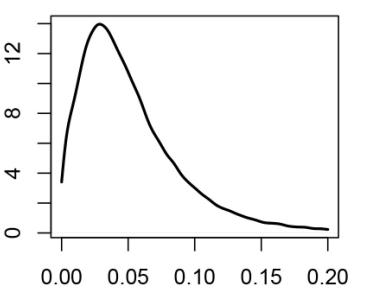
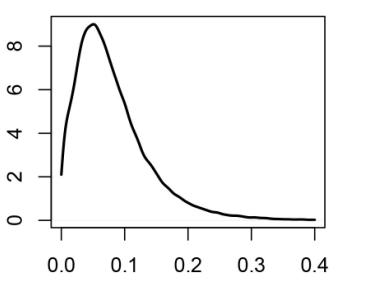
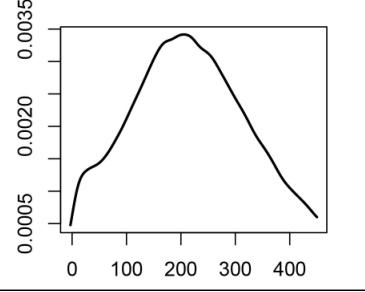
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Agricultural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.002 0.013 0.018 0.060	 <p>A graph showing the probability distribution of concentrations for agricultural soils. The x-axis is labeled 'Concentration' and ranges from 0.00 to 0.08. The y-axis is labeled 'Probability' and ranges from 0 to 30. A bell-shaped curve is centered around a concentration of approximately 0.018.</p>	annual accumulation $\mu\text{g}/\text{kg}$
Natural soils 0.004 0.028 0.043 0.162		 <p>A graph showing the probability distribution of concentrations for natural soils. The x-axis is labeled 'Concentration' and ranges from 0.00 to 0.20. The y-axis ranges from 0 to 12. A bell-shaped curve is centered around a concentration of approximately 0.043.</p>	annual accumulation $\mu\text{g}/\text{kg}$
Urban soils 0.006 0.051 0.068 0.233		 <p>A graph showing the probability distribution of concentrations for urban soils. The x-axis is labeled 'Concentration' and ranges from 0.0 to 0.4. The y-axis ranges from 0 to 8. A bell-shaped curve is centered around a concentration of approximately 0.068.</p>	annual accumulation $\mu\text{g}/\text{kg}$
Sludge treated soils 19.903 204.948 216.083 472.618		 <p>A graph showing the probability distribution of concentrations for sludge-treated soils. The x-axis is labeled 'Concentration' and ranges from 0 to 400. The y-axis ranges from 0.0005 to 0.0035. A bell-shaped curve is centered around a concentration of approximately 204.948.</p>	annual accumulation $\mu\text{g}/\text{kg}$

TABLE 3.

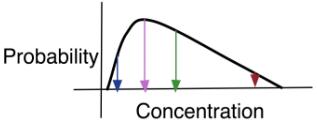
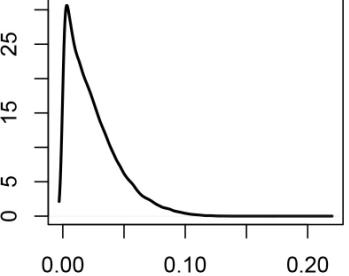
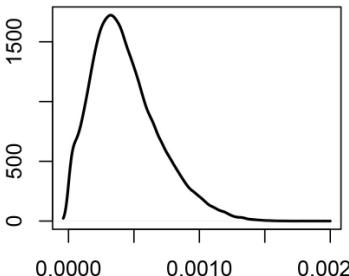
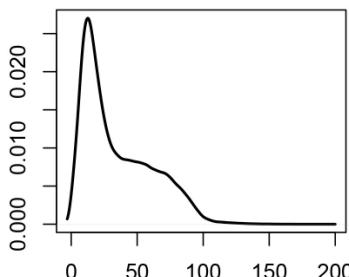
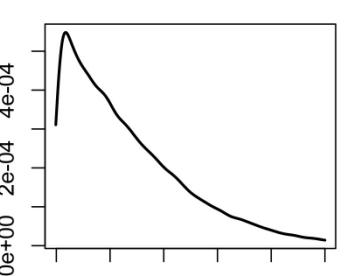
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit
Surface water (fresh water)	Min (2.5% quantile) 0.001 Mode value 0.003 Median 0.019 Max (97.5% quantile) 0.078		$\mu\text{g/l}$
Sea water	4.04E-05 3.21E-04 3.95E-04 0.001		$\mu\text{g/l}$
Sewage treatment effluent	3.418 12.608 26.235 91.908		$\mu\text{g/l}$
Sediments (fresh water)	31.145 180.301 1048.584 4292.268		annual accumul $\mu\text{g/kg}$

TABLE 4.

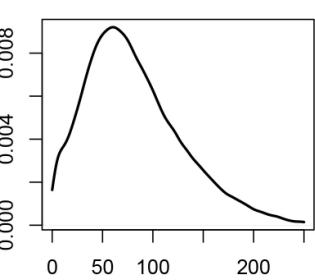
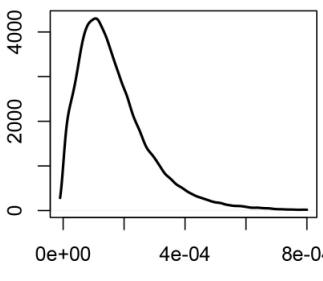
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sediments (sea water)	Min (2.5% quantile) 7.556 Mode value 60.101 Median 73.874 Max (97.5% quantile) 195.282		annual accumulation $\mu\text{g}/\text{kg}$
Air	1.3E-05 1.1E-04 1.4E-04 4.9E-04		$\mu\text{g}/\text{m}^3$

TABLE 5.

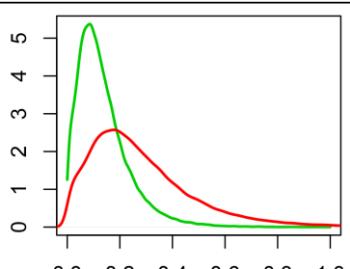
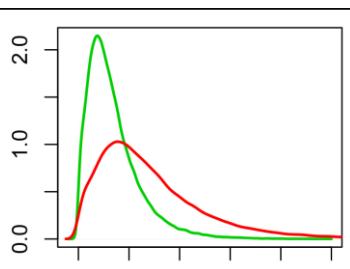
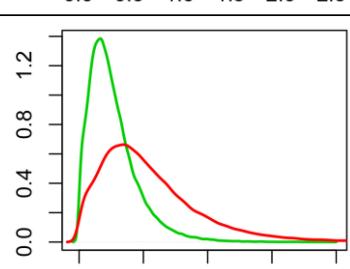
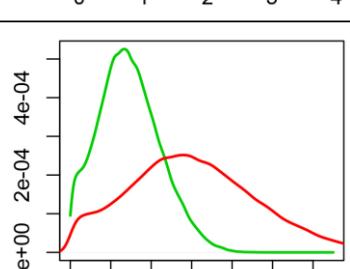
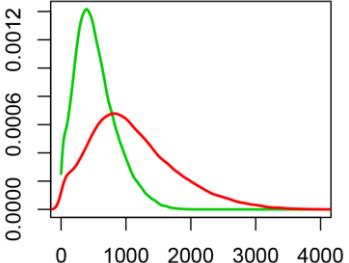
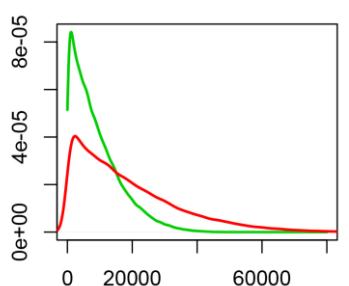
Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Agricultural soils			
Min (2.5% quantile)	0.010 0.021		
Mode value	0.085 0.178		
Median	0.114 0.238		
Max (97.5% quantile)	0.390 0.815		µg/kg
Natural soils			
	0.024 0.050		
	0.183 0.382		
	0.282 0.588		
	1.053 2.199		µg/kg
Urban soils			
	0.039 0.082		
	0.331 0.690		
	0.443 0.924		
	1.514 3.161		µg/kg
Sludge treated soils			
	129.368 270.109		
	1332.160 2781.433		
	1404.538 2932.551		
	3072.018 6414.103		µg/kg

TABLE 6.

Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Sediments (sea water)			
Min (2.5% quantile)	49.116 102.549		
Mode value	390.654 815.651		µg/kg
Median	480.181 1002.575		
Max (97.5% quantile)	1269.334 2650.258		
Sediments (fresh water)			
	202.440 422.677		
	1171.958 2446.945		µg/kg
	6815.793 14230.780		
	27899.740 58252.210		

3.3 Photocatalytic titanium dioxide (TiO₂)

TABLES 7-12.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR PHOTOCATALYTIC NANO-TiO₂ DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

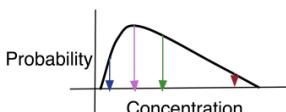
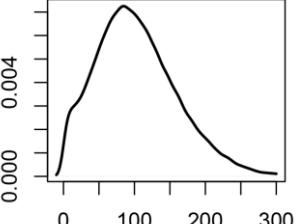
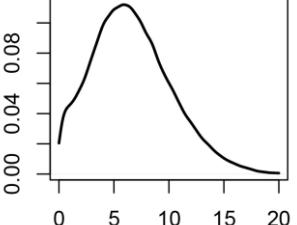
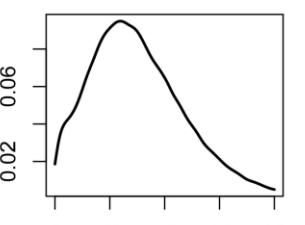
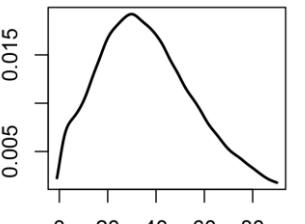
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Sewage treatment sludge	Min (2.5% quantile) 9.256 Mode value 84.618 Median 97.163 Max (97.5% quantile) 232.438		mg/kg
Waste mass incinerated	0.284 2.776 2.975 6.838		mg/kg
Bottom ash of waste incineration	0.672 5.952 7.099 18.287		mg/kg
Fly ash of waste incineration	3.324 29.726 35.169 90.427		mg/kg

TABLE 8.

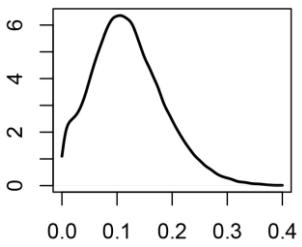
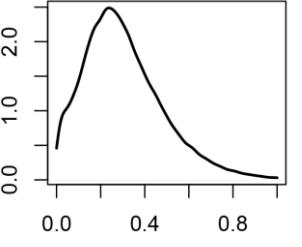
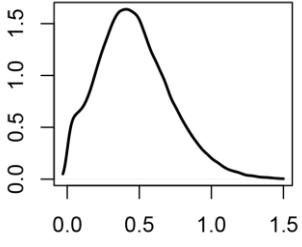
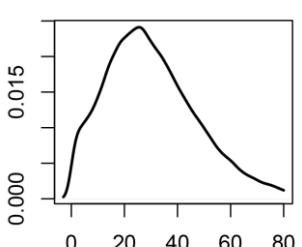
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Agricultural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.011 0.105 0.114 0.265		annual accumulation $\mu\text{g}/\text{kg}$
Natural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.027 0.237 0.280 0.747		annual accumulation $\mu\text{g}/\text{kg}$
Urban soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.044 0.409 0.444 1.029		annual accumulation $\mu\text{g}/\text{kg}$
Sludge treated soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	2.679 25.511 28.375 73.364		annual accumulation $\mu\text{g}/\text{kg}$

TABLE 9.

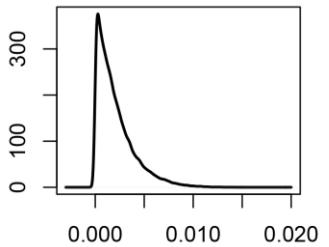
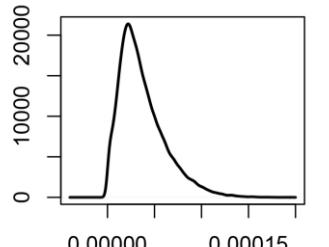
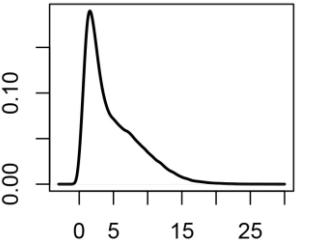
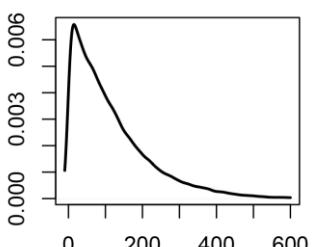
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Surface water (fresh water)	Min (2.5% quantile) 4.7E-05 Mode value 2.7E-04 Median 0.002 Max (97.5% quantile) 0.007	 <p>A probability distribution plot with 'Probability' on the y-axis (0 to 300) and 'Concentration' on the x-axis (0.000 to 0.020). The curve is very narrow and shifted towards zero, peaking near 0.002.</p>	$\mu\text{g/l}$
Sea water	3.6E-06 2.2E-05 3.2E-05 9.9E-05	 <p>A probability distribution plot with 'Probability' on the y-axis (0 to 20000) and 'Concentration' on the x-axis (0.00000 to 0.00015). The curve is broader than the one for surface water.</p>	$\mu\text{g/l}$
Sewage treatment effluent	0.441 1.563 3.571 14.280	 <p>A probability distribution plot with 'Probability' on the y-axis (0.00 to 0.10) and 'Concentration' on the x-axis (0 to 25). The curve peaks sharply at a low concentration value.</p>	$\mu\text{g/l}$
Sediments (fresh water)	2.611 14.193 86.776 401.144	 <p>A probability distribution plot with 'Probability' on the y-axis (0.000 to 0.006) and 'Concentration' on the x-axis (0 to 600). The curve is extremely narrow and shifted towards zero.</p>	annual accumulation $\mu\text{g/kg}$

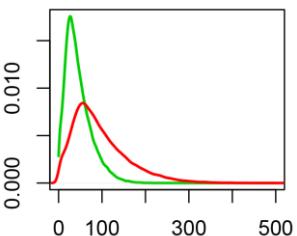
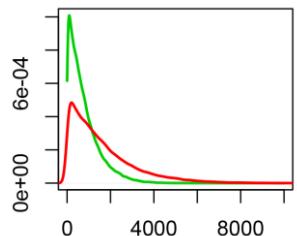
TABLE 10.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Sediments (sea water)	Min (2.5% quantile) 0.669 Mode value 4.078 Median 5.910 Max (97.5% quantile) 18.453		annual accumulation μg/kg
Air	7.7E-05 7.3E-04 0.001 0.002		μg/m³

TABLE 11.

Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Agricultural soils			
Min (2.5% quantile)	0.073	0.153	
Mode value	0.685	1.431	
Median	0.743	1.552	
Max (97.5% quantile)	1.724	3.599	µg/kg
Natural soils			
	0.177	0.370	
	1.538	3.211	
	1.817	3.794	
	4.857	10.142	µg/kg
Urban soils			
	0.284	0.593	
	2.659	5.552	
	2.884	6.021	
	6.688	13.964	µg/kg
Sludge treated soils			
	17.412	36.355	
	165.821	346.219	
	184.436	385.087	
	476.867	995.656	µg/kg

TABLE 12.

Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Sediments (sea water)			
Min (2.5% quantile)	4.345 9.073		
Mode value	26.508 55.346		
Median	38.418 80.213		
Max (97.5% quantile)	119.943 250.430		µg/kg
Sediments (fresh water)			
	16.973 35.437		
	92.253 192.615		
	564.044 1177.674		
	2607.438 5444.102		µg/kg

3.4 Zinc oxide (ZnO)

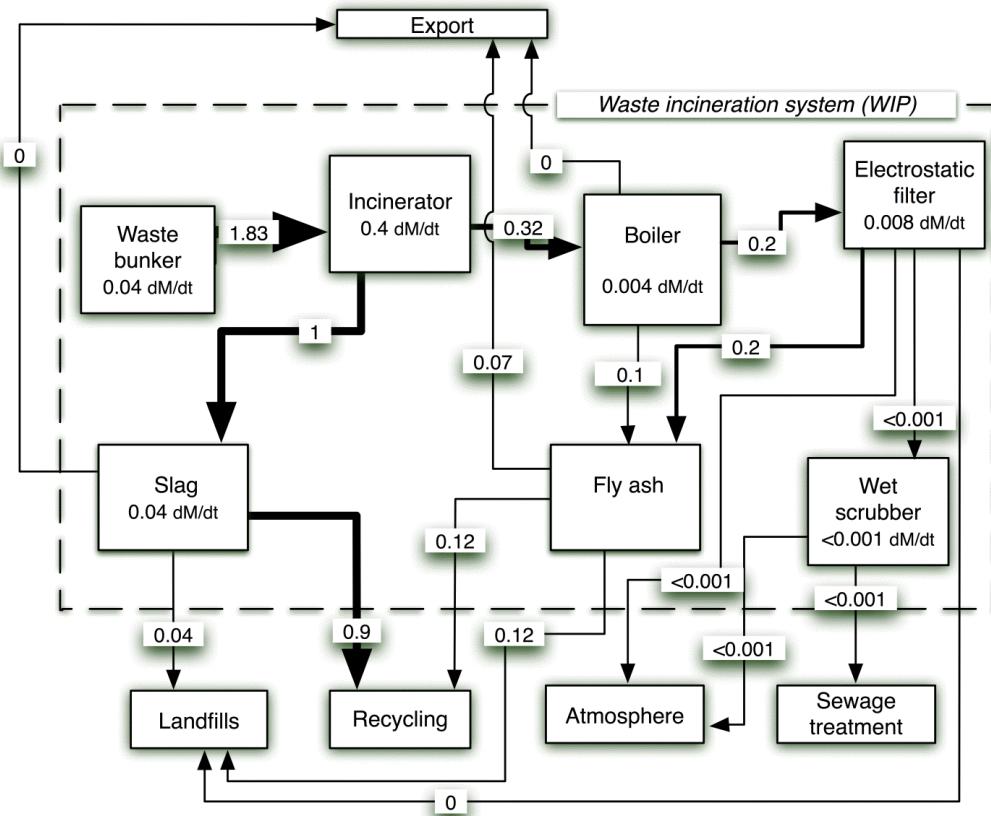


FIGURE 4.

SYSTEM GEOMETRY OF THE WASTE INCINERATION PLANT (WIP) WITH STUDIED COMPARTMENTS AND ENGINEERED NANOMATERIAL (ZnO) FLOWS IN T/A, ACCUMULATION OR TRANSFORMATION MASS (POSITIVE OR NEGATIVE MASS VALUES IN THE BOXES) SHOWN AS ROUNDED MEDIAN. SUCH ROUNDED – IN THIS CASE MEDIAN VALUES (EXTRACTED FROM ALL THE MONTE CARLO SIMULATIONS) – REPRESENT HIGH PROBABILITY RESULTS AT ALL DIFFERENT STAGES OF THE WIP WITHOUT PRECISELY ILLUSTRATING IN THE FIGURE MASS-BALANCE FROM A WHOLE PERSPECTIVE.

TABLES 13-18.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR NANO-ZnO DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

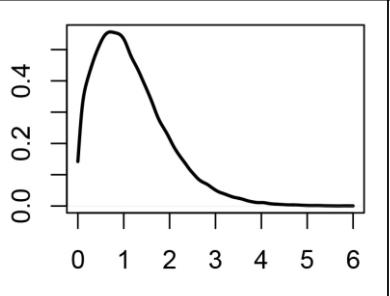
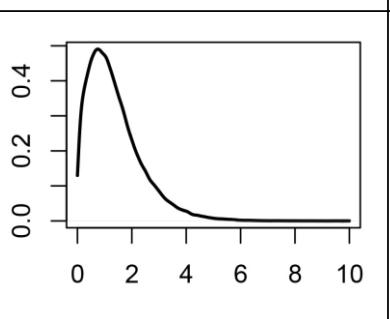
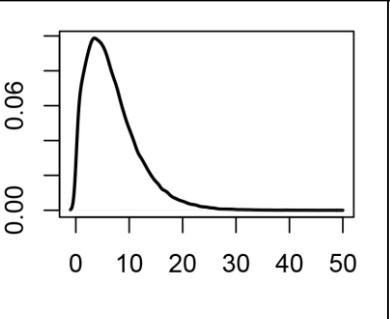
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sewage treatment sludge Min (2.5% quantile) Mode value Median Max (97.5% quantile)		Almost no nano-ZnO is remaining in nanoform in this compartment.	mg/kg
Waste mass incinerated	0.042 0.338 0.487 1.488		mg/kg
Bottom ash of waste incineration	0.100 0.739 1.164 3.884		mg/kg
Fly ash of waste incineration	0.492 3.552 5.782 19.209		mg/kg

TABLE 14.

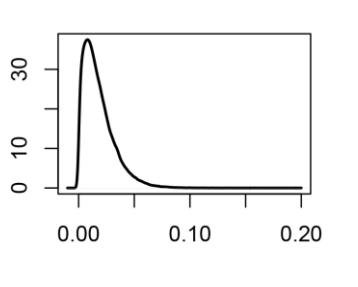
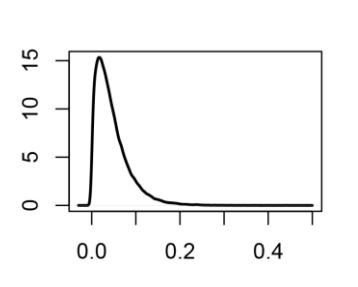
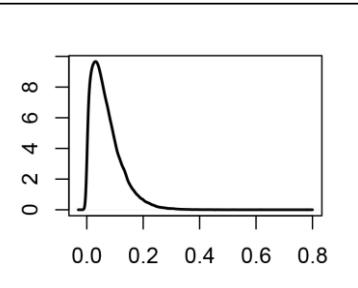
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Agricultural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.001 0.008 0.015 0.053	 <p>A probability distribution graph for Agricultural soils. The x-axis is labeled 'Concentration' and ranges from 0.00 to 0.20. The y-axis is labeled 'Probability' and ranges from 0 to 30. The distribution is highly skewed to the right, with a very sharp peak at approximately 0.01 concentration and rapidly decaying probability thereafter.</p>	annual accumulation $\mu\text{g}/\text{kg}$
Natural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.003 0.017 0.036 0.145	 <p>A probability distribution graph for Natural soils. The x-axis is labeled 'Concentration' and ranges from 0.0 to 0.4. The y-axis is labeled 'Probability' and ranges from 0 to 15. The distribution is highly skewed to the right, with a very sharp peak at approximately 0.02 concentration and rapidly decaying probability thereafter.</p>	annual accumulation $\mu\text{g}/\text{kg}$
Urban soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.005 0.031 0.057 0.207	 <p>A probability distribution graph for Urban soils. The x-axis is labeled 'Concentration' and ranges from 0.0 to 0.8. The y-axis is labeled 'Probability' and ranges from 0 to 8. The distribution is highly skewed to the right, with a very sharp peak at approximately 0.02 concentration and rapidly decaying probability thereafter.</p>	annual accumulation $\mu\text{g}/\text{kg}$
Sludge treated soils		See please comments for STP sludge.	annual accumulation $\mu\text{g}/\text{kg}$

TABLE 15.

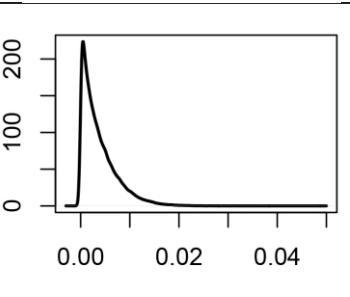
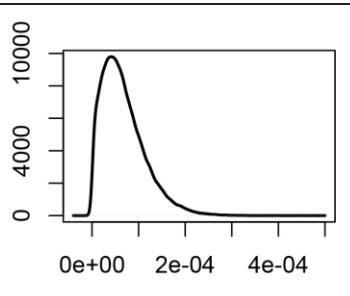
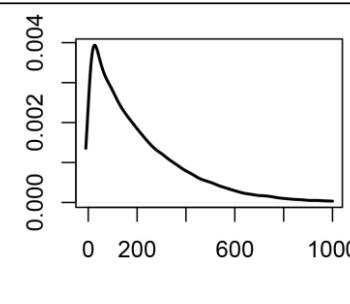
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Surface water (fresh water)	Min (2.5% quantile) 8.6E-05 Mode value 4.5E-04 Median 2.7E-03 Max (97.5% quantile) 1.3E-02	 <p>A probability distribution plot for Surface water (fresh water). The x-axis is labeled 'Concentration' and ranges from 0.00 to 0.04. The y-axis is labeled 'Probability' and ranges from 0 to 200. The distribution is highly skewed to the right, with the highest probability density near zero concentration.</p>	$\mu\text{g/l}$
Sea water	5.6E-06 4.1E-05 5.8E-05 1.8E-04	 <p>A probability distribution plot for Sea water. The x-axis is labeled 'Concentration' and ranges from 0e+00 to 4e-04. The y-axis is labeled 'Probability' and ranges from 0 to 10000. The distribution is highly skewed to the right, with the highest probability density near zero concentration.</p>	$\mu\text{g/l}$
Sewage treatment effluent	0	Almost no nano-ZnO is ending up in nanoform in this compartment.	$\mu\text{g/l}$
Sediments (fresh water)	4.548 25.205 152.791 734.561	 <p>A probability distribution plot for Sediments (fresh water). The x-axis is labeled 'Concentration' and ranges from 0 to 1000. The y-axis is labeled 'Probability' and ranges from 0.0000 to 0.004. The distribution is highly skewed to the right, with the highest probability density near zero concentration.</p>	annual accumulation $\mu\text{g/kg}$

TABLE 16.

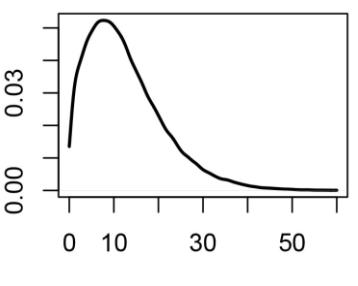
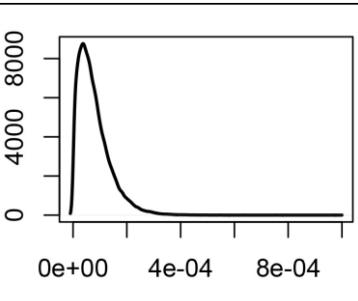
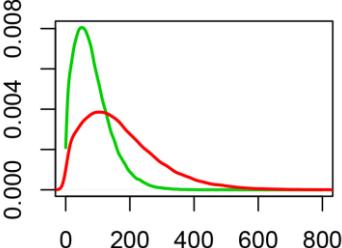
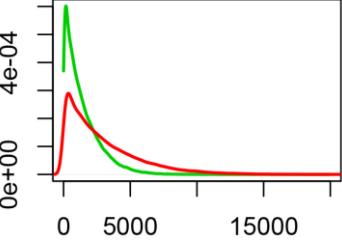
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sediments (sea water)	Min (2.5% quantile) 0.940 Mode value 7.593 Median 10.945 Max (97.5% quantile) 33.830		annual accumulation $\mu\text{g}/\text{kg}$
Air	5.20E-06 3.65E-05 6.39E-05 2.3E-04		$\mu\text{g}/\text{m}^3$

TABLE 17.

Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Agricultural soils			
Min (2.5% quantile)	0.008	0.016	
Mode value	0.052	0.108	
Median	0.095	0.199	
Max (97.5% quantile)	0.347	0.724	µg/kg
Natural soils	0.018 0.122 0.235 0.941	0.038 0.228 0.492 1.965	µg/kg
Urban soils	0.030 0.200 0.370 1.346	0.062 0.418 0.773 2.810	µg/kg
Sludge treated soils		See please comments for STP sludge.	µg/kg

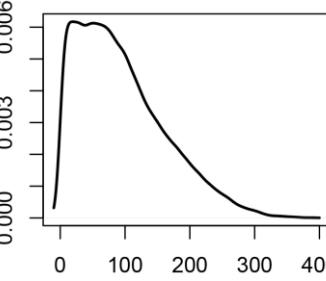
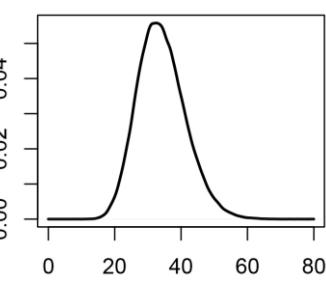
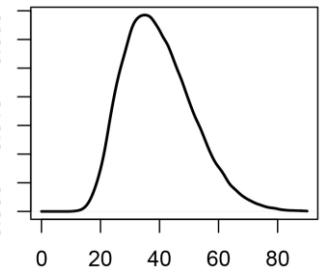
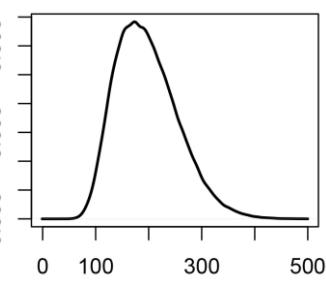
TABLE 18.

Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Sediments (sea water)			
Min (2.5% quantile)	6.110	12.758	
Mode value	49.353	103.045	µg/kg
Median	71.144	148.541	
Max (97.5% quantile)	219.894	459.120	
Sediments (fresh water)			
	29.564	61.727	
	163.834	342.072	µg/kg
	993.144	2073.598	
	4774.644	9969.036	

3.5 Silver (AgNP)

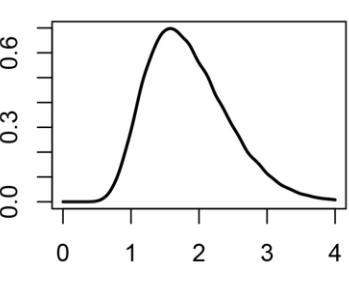
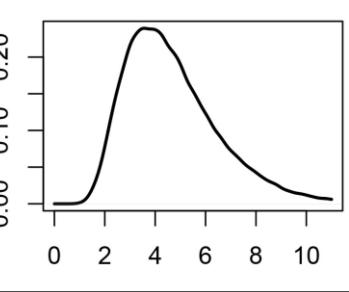
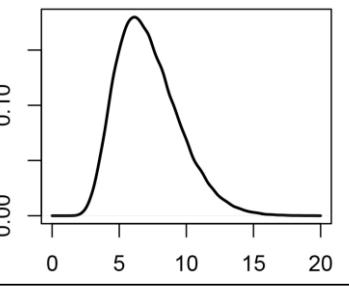
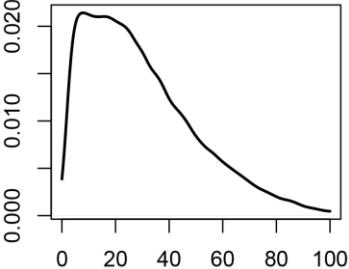
TABLES 19-24.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR NANO-Ag DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sewage treatment sludge	4.165 * 82.121 254.192	 <p>A probability distribution plot for sewage treatment sludge. The x-axis is labeled 'Concentration' and ranges from 0 to 400. The y-axis is labeled 'Probability' and ranges from 0.000 to 0.006. The distribution is skewed to the right, starting at a low probability near zero and rising sharply to a peak around 50, then gradually decreasing towards zero.</p>	$\mu\text{g}/\text{kg}$
Waste mass incinerated	10.131 15.300 15.833 23.376	 <p>A probability distribution plot for waste mass incinerated. The x-axis is labeled and ranges from 0 to 80. The y-axis is labeled and ranges from 0.00 to 0.04. The distribution is very narrow and centered around 35, with a peak probability of approximately 0.04.</p>	$\mu\text{g}/\text{kg}$
Bottom ash of waste incineration	20.874 34.927 38.342 65.651	 <p>A probability distribution plot for bottom ash of waste incineration. The x-axis is labeled and ranges from 0 to 80. The y-axis is labeled and ranges from 0.000 to 0.030. The distribution is broader than the incinerated waste, peaking around 35 with a probability of about 0.03.</p>	$\mu\text{g}/\text{kg}$
Fly ash of waste incineration	103.230 174.011 190.441 326.559	 <p>A probability distribution plot for fly ash of waste incineration. The x-axis is labeled and ranges from 0 to 500. The y-axis is labeled and ranges from 0.000 to 0.006. The distribution is extremely wide and flat, with a very low peak probability of about 0.0005 occurring around 150.</p>	$\mu\text{g}/\text{kg}$

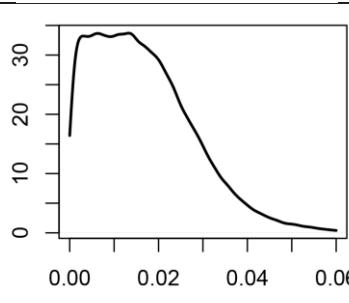
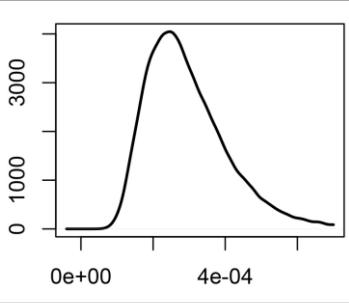
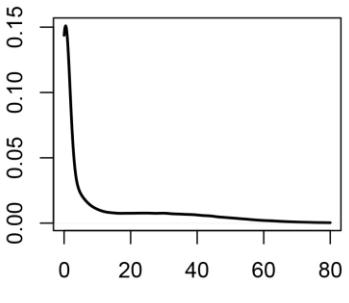
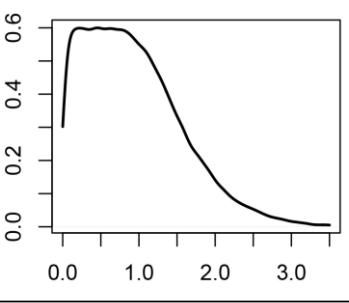
*inconclusive, bipolar (or pluripolar) or insignifant difference to median

TABLE 20.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Agricultural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.907 1.580 1.770 3.211		annual accumulation ng/kg
Natural soils 1.999 3.671 4.370 9.329			annual accumulation ng/kg
Urban soils 3.518 6.132 6.866 12.457			annual accumulation ng/kg
Sludge treated soils 3.004 * 25.743 81.577			annual accumulation ng/kg

*inconclusive, bipolar (or pluripolar) or insignifant difference to median

TABLE 21.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Surface water (fresh water)	≈ 0 * 0.015 0.044	 <p>A probability distribution plot for Surface water (fresh water). The x-axis is labeled 'Concentration' and ranges from 0.00 to 0.06. The y-axis is labeled 'Probability' and ranges from 0 to 30. The distribution is right-skewed, peaking at a concentration of approximately 0.015.</p>	ng/l
Sea water	≈ 0 2.5E-04 2.8E-04 0.001	 <p>A probability distribution plot for Sea water. The x-axis is labeled 'Concentration' and ranges from 0e+00 to 4e-04. The y-axis ranges from 0 to 3000. The distribution is very sharp and peaked at a concentration of approximately 0.001.</p>	ng/l
Sewage treatment effluent	0.012 0.453 1.735 58.603	 <p>A probability distribution plot for Sewage treatment effluent. The x-axis ranges from 0 to 80. The y-axis ranges from 0.00 to 0.15. The distribution is very sharp and peaked at a concentration of approximately 0.012.</p>	ng/l
Sediments (fresh water)	≈ 0 * 0.838 2.445	 <p>A probability distribution plot for Sediments (fresh water). The x-axis ranges from 0.0 to 3.0. The y-axis ranges from 0.0 to 0.6. The distribution is right-skewed, peaking at a concentration of approximately 0.838.</p>	annual accumulation $\mu\text{g}/\text{kg}$

*inconclusive, bipolar (or pluripolar) or insignifant difference to median

TABLE 22.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass																										
Sediments (sea water)	Min (2.5% quantile) Mode value Median Max (97.5% quantile)	<table border="1"> <caption>Data for Sediments (sea water) Probability Distribution</caption> <thead> <tr> <th>Concentration</th> <th>Probability</th> </tr> </thead> <tbody> <tr><td>0.00</td><td>0.00</td></tr> <tr><td>0.02</td><td>1.0</td></tr> <tr><td>0.04</td><td>10.0</td></tr> <tr><td>0.05</td><td>18.0</td></tr> <tr><td>0.06</td><td>15.0</td></tr> <tr><td>0.08</td><td>5.0</td></tr> <tr><td>0.10</td><td>1.0</td></tr> <tr><td>0.12</td><td>0.5</td></tr> <tr><td>0.15</td><td>0.2</td></tr> <tr><td>0.20</td><td>0.1</td></tr> <tr><td>0.25</td><td>0.05</td></tr> <tr><td>0.30</td><td>0.02</td></tr> </tbody> </table>	Concentration	Probability	0.00	0.00	0.02	1.0	0.04	10.0	0.05	18.0	0.06	15.0	0.08	5.0	0.10	1.0	0.12	0.5	0.15	0.2	0.20	0.1	0.25	0.05	0.30	0.02	annual accumulation μg/kg
Concentration	Probability																												
0.00	0.00																												
0.02	1.0																												
0.04	10.0																												
0.05	18.0																												
0.06	15.0																												
0.08	5.0																												
0.10	1.0																												
0.12	0.5																												
0.15	0.2																												
0.20	0.1																												
0.25	0.05																												
0.30	0.02																												
Air	0.004 0.007 0.007 0.011	<table border="1"> <caption>Data for Air Probability Distribution</caption> <thead> <tr> <th>Concentration</th> <th>Probability</th> </tr> </thead> <tbody> <tr><td>0.000</td><td>0.00</td></tr> <tr><td>0.002</td><td>1.0</td></tr> <tr><td>0.004</td><td>10.0</td></tr> <tr><td>0.005</td><td>150.0</td></tr> <tr><td>0.006</td><td>100.0</td></tr> <tr><td>0.008</td><td>50.0</td></tr> <tr><td>0.010</td><td>10.0</td></tr> <tr><td>0.012</td><td>1.0</td></tr> <tr><td>0.015</td><td>0.5</td></tr> <tr><td>0.020</td><td>0.1</td></tr> </tbody> </table>	Concentration	Probability	0.000	0.00	0.002	1.0	0.004	10.0	0.005	150.0	0.006	100.0	0.008	50.0	0.010	10.0	0.012	1.0	0.015	0.5	0.020	0.1	ng/m ³				
Concentration	Probability																												
0.000	0.00																												
0.002	1.0																												
0.004	10.0																												
0.005	150.0																												
0.006	100.0																												
0.008	50.0																												
0.010	10.0																												
0.012	1.0																												
0.015	0.5																												
0.020	0.1																												

TABLE 23.

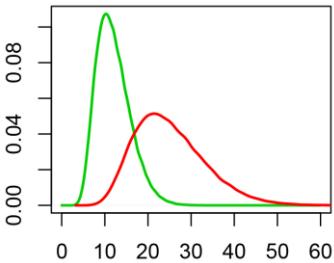
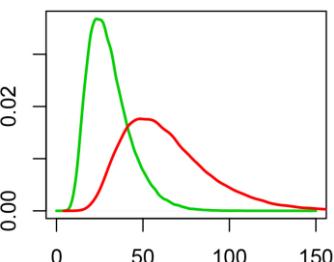
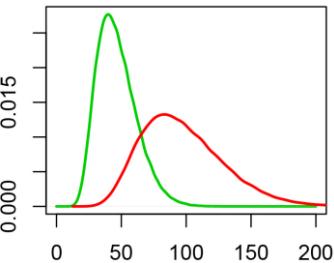
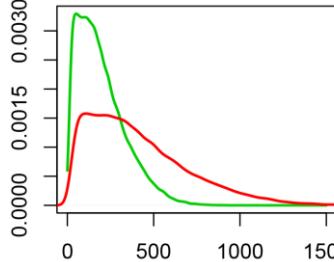
Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Agricultural soils			
Min (2.5% quantile)	5.893 12.304		ng/kg
Mode value	10.272 21.447		
Median	11.502 24.015		
Max (97.5% quantile)	20.869 43.572		
Natural soils			
	12.996 27.134		ng/kg
	23.863 49.824		
	28.406 59.309		
	60.641 126.614		
Urban soils			
	22.864 47.738		ng/kg
	39.855 83.215		
	44.627 93.178		
	80.970 169.058		
Sludge treated soils			
	19.527 40.771		ng/kg
	51.071 106.631		
	167.327 349.363		
	530.251 1107.117		

TABLE 24.

Concentrations	Statistical values	Probability distributions	Unit
	Min (2.5% quantile) Mode value Median Max (97.5% quantile)	green curves results for 2014 red curves results for 2020	mass/mass
Sediments (sea water)			
Min (2.5% quantile)	≈0	≈0	
Mode value	0.300	0.626	
Median	0.335	0.700	
Max (97.5% quantile)	0.711	1.485	μg/kg
Sediments (fresh water)			
	≈0	≈0	
	*	*	
	5.446	11.371	
	15.889	33.176	μg/kg

*inconclusive, bipolar (or pluripolar) or insignifant difference to median

3.6 Carbon nanotubes (CNT)

TABLES 25-30.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR CNT DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

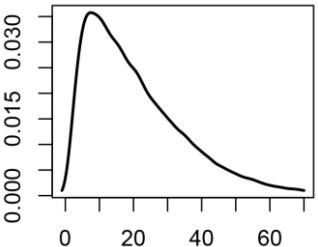
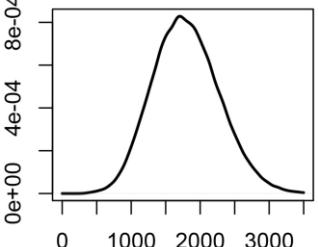
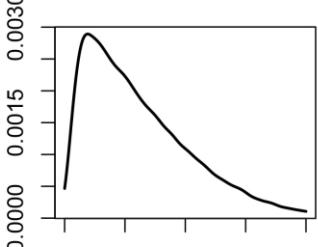
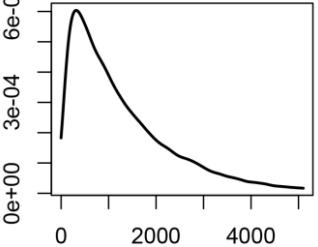
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sewage treatment sludge	2.692 7.626 17.399 61.608	 <p>The graph shows a probability distribution curve for the concentration of CNT in sewage treatment sludge. The x-axis is labeled 'Concentration' and ranges from 0 to 60. The y-axis is labeled 'Probability' and ranges from 0.0000 to 0.0300. The curve is unimodal and symmetric, peaking at a concentration of approximately 17.399.</p>	$\mu\text{g}/\text{kg}$
Waste mass incinerated	435.867 801.863 837.423 1316.897	 <p>The graph shows a probability distribution curve for the concentration of CNT in waste mass incinerated. The x-axis is labeled and ranges from 0 to 3000. The y-axis is labeled and ranges from 0e+00 to 8e-04. The curve is unimodal and symmetric, peaking at a concentration of approximately 837.423.</p>	$\mu\text{g}/\text{kg}$
Bottom ash of waste incineration	26.473 75.729 209.537 710.924	 <p>The graph shows a probability distribution curve for the concentration of CNT in bottom ash of waste incineration. The x-axis is labeled and ranges from 0 to 800. The y-axis is labeled and ranges from 0.00000 to 0.0030. The curve is unimodal and symmetric, peaking at a concentration of approximately 209.537.</p>	$\mu\text{g}/\text{kg}$
Fly ash of waste incineration	87.871 325.573 994.664 4774.219	 <p>The graph shows a probability distribution curve for the concentration of CNT in fly ash of waste incineration. The x-axis is labeled and ranges from 0 to 4000. The y-axis is labeled and ranges from 0e+00 to 6e-04. The curve is unimodal and symmetric, peaking at a concentration of approximately 994.664.</p>	$\mu\text{g}/\text{kg}$

TABLE 26.

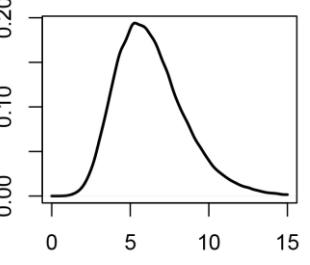
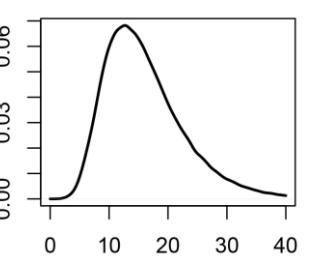
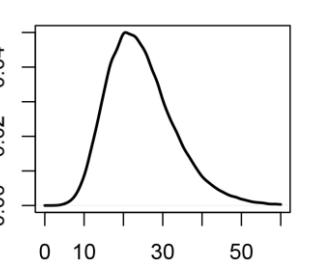
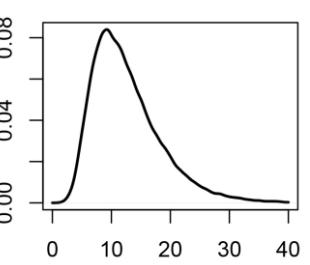
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Agricultural soils	Min (2.5% quantile) 2.822 Mode value 5.305 Median 6.048 Max (97.5% quantile) 11.546	 <p>A bell-shaped probability distribution curve for agricultural soils. The x-axis is labeled 'Concentration' and ranges from 0 to 15. The y-axis is labeled 'Probability' and ranges from 0.00 to 0.20. The peak of the curve is at approximately 6.048.</p>	annual accumulation ng/kg
Natural soils	6.301 12.696 14.900 33.094	 <p>A bell-shaped probability distribution curve for natural soils. The x-axis is labeled 'Concentration' and ranges from 0 to 40. The y-axis is labeled 'Probability' and ranges from 0.00 to 0.06. The peak of the curve is at approximately 14.900.</p>	annual accumulation ng/kg
Urban soils	10.951 20.582 23.465 44.799	 <p>A bell-shaped probability distribution curve for urban soils. The x-axis is labeled 'Concentration' and ranges from 0 to 50. The y-axis is labeled 'Probability' and ranges from 0.00 to 0.04. The peak of the curve is at approximately 23.465.</p>	annual accumulation ng/kg
Sludge treated soils	4.634 9.199 11.518 27.377	 <p>A bell-shaped probability distribution curve for sludge treated soils. The x-axis is labeled 'Concentration' and ranges from 0 to 40. The y-axis is labeled 'Probability' and ranges from 0.00 to 0.08. The peak of the curve is at approximately 11.518.</p>	annual accumulation ng/kg

TABLE 27.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Surface water (fresh water)	Min (2.5% quantile) 1.8E-04 Mode value 0.001 Median 0.004 Max (97.5% quantile) 0.015		ng/l
Sea water	2.2E-05 4.9E-05 7.0E-05 2.0E-04		ng/l
Sewage treatment effluent	0.097 0.301 0.724 3.461		ng/l
Sediments (fresh water)	0.011 0.074 0.222 0.854		annual accumulation μg/kg

TABLE 28.

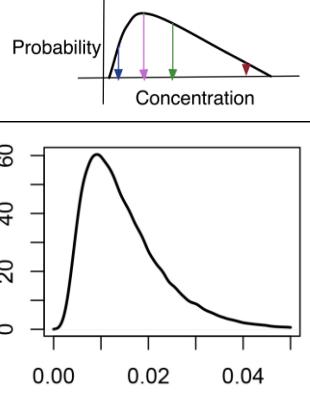
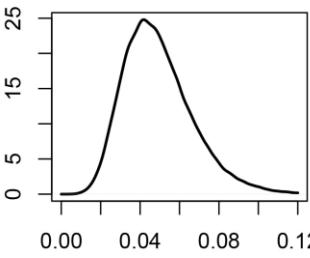
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sediments (sea water)	Min (2.5% quantile) 0.004 Mode value 0.009 Median 0.013 Max (97.5% quantile) 0.038		annual accumulation μg/kg
Air	0.022 0.042 0.047 0.091		ng/m³

TABLE 29.

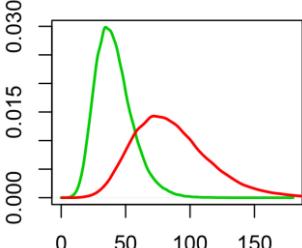
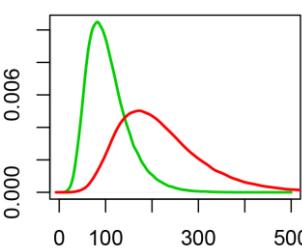
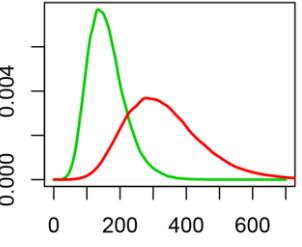
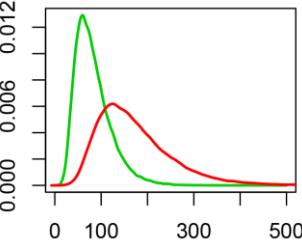
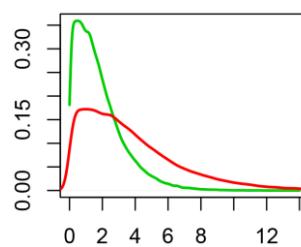
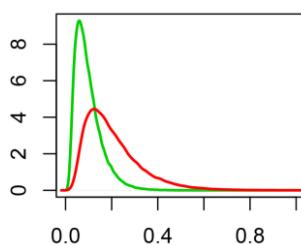
Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Agricultural soils			
Min (2.5% quantile)	18.345 38.303		ng/kg
Mode value	34.481 71.992		
Median	39.310 82.076		
Max (97.5% quantile)	75.050 156.698		
Natural soils			
	40.955 85.511		ng/kg
	82.527 172.310		
	96.849 202.211		
	215.113 449.137		
Urban soils			
	71.179 148.616		ng/kg
	133.785 279.330		
	152.524 318.456		
	291.194 607.988		
Sludge treated soils			
	30.119 62.885		ng/kg
	59.791 124.838		
	74.868 156.318		
	177.949 371.541		

TABLE 30.

Concentrations	Statistical values	Probability distributions	Unit
	Min (2.5% quantile) Mode value Median Max (97.5% quantile)	green curves results for 2014 red curves results for 2020	mass/mass
Sediments (sea water)			
Min (2.5% quantile)	0.026	0.055	
Mode value	0.060	0.125	
Median	0.085	0.177	
Max (97.5% quantile)	0.245	0.511	
Sediments (fresh water)			
	0.070	0.145	
	0.480	1.002	
	1.441	3.008	
	5.554	11.596	



3.7 Nano-copper carbonate (CuCO_3)

TABLES 31-36.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR NANO-COPPER CARBONATE DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

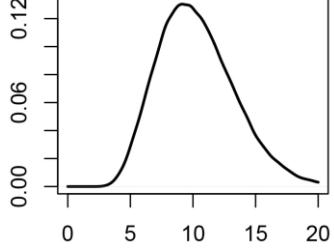
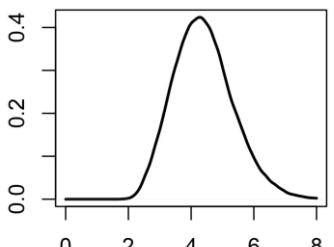
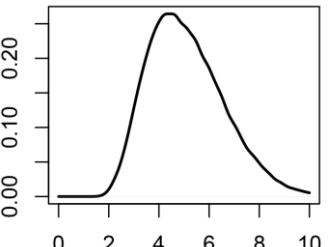
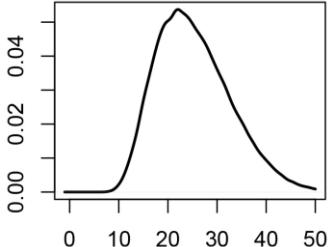
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sewage treatment sludge	Min (2.5% quantile) 5.177 Mode value 9.120 Median 10.010 Max (97.5% quantile) 17.205	 <p>A probability distribution plot for sewage treatment sludge. The x-axis is labeled 'Concentration' and ranges from 0 to 20 with major ticks every 5 units. The y-axis is labeled 'Probability' and ranges from 0.00 to 0.12 with major ticks every 0.06 units. A smooth black curve represents the distribution, starting near zero, rising to a peak at approximately 10, and then gradually declining towards zero.</p>	mg/kg
Waste mass incinerated	1.289 2.015 2.040 3.040	 <p>A probability distribution plot for waste mass incinerated. The x-axis is labeled and ranges from 0 to 8 with major ticks every 2 units. The y-axis ranges from 0.0 to 0.4 with major ticks every 0.2 units. A smooth black curve peaks sharply at approximately 4.</p>	mg/kg
Bottom ash of waste incineration	2.663 4.369 4.926 8.501	 <p>A probability distribution plot for bottom ash of waste incineration. The x-axis is labeled and ranges from 0 to 10 with major ticks every 2 units. The y-axis ranges from 0.00 to 0.20 with major ticks every 0.10 units. A smooth black curve peaks at approximately 5.</p>	mg/kg
Fly ash of waste incineration	13.204 22.077 24.450 42.267	 <p>A probability distribution plot for fly ash of waste incineration. The x-axis is labeled and ranges from 0 to 50 with major ticks every 10 units. The y-axis ranges from 0.00 to 0.04 with major ticks every 0.02 units. A smooth black curve peaks at approximately 25.</p>	mg/kg

TABLE 32.

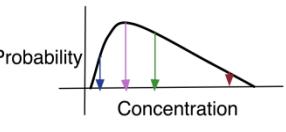
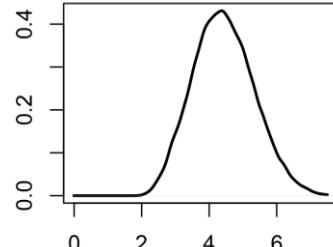
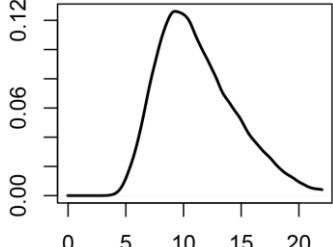
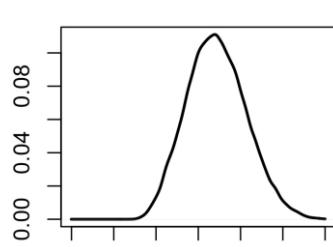
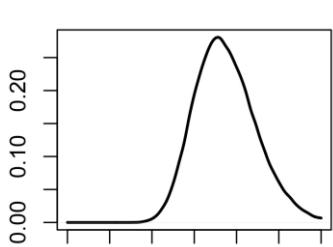
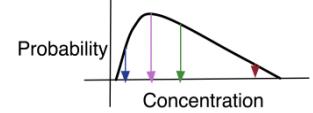
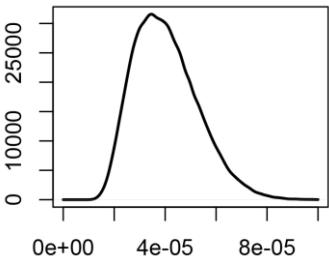
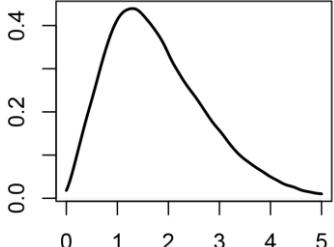
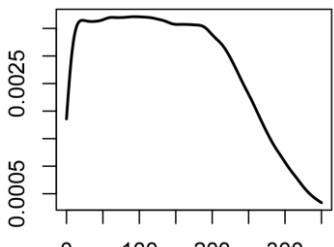
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Agricultural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	2.782 4.371 4.394 6.290		annual accumulation µg/kg
Natural soils 5.941 9.284 10.705 19.399			annual accumulation µg/kg
Urban soils 10.793 16.961 17.049 24.404			annual accumulation µg/kg
Sludge treated soils 4.982 7.116 7.382 10.695			annual accumulation µg/kg

TABLE 33.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Surface water (fresh water)	Min (2.5% quantile) 1.2E-04 Mode value * Median 2.4E-03 Max (97.5% quantile) 5.7E-03		$\mu\text{g/l}$
Sea water	2.0E-05 3.5E-05 3.9E-05 6.8E-05		$\mu\text{g/l}$
Sewage treatment effluent	0.320 1.300 1.637 4.123		$\mu\text{g/l}$
Sediments (fresh water)	6.672 * 135.947 321.734		annual accumulation $\mu\text{g/kg}$

*inconclusive, bipolar (or pluripolar) or insignifant difference to median

TABLE 34.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Sediments (sea water)	Min (2.5% quantile) 3.789 Mode value 6.486 Median 7.289 Max (97.5% quantile) 12.776		annual accumulation µg/kg
Air	4.60E-06 2.12E-05 2.05E-05 3.87E-05		µg/m³

TABLE 35.

Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Agricultural soils			
Min (2.5% quantile)	18.081	37.752	
Mode value	28.413	59.325	
Median	28.562	59.635	
Max (97.5% quantile)	40.883	85.360	µg/kg
Natural soils			
	38.617	80.629	
	60.348	126.001	
	69.584	145.286	
	126.093	263.272	µg/kg
Urban soils			
	70.155	146.477	
	110.244	230.180	
	110.821	231.384	
	158.627	331.199	µg/kg
Sludge treated soils			
	32.385	67.618	
	46.254	96.574	
	47.983	100.184	
	69.519	145.149	µg/kg

TABLE 36.

Concentrations	Statistical values	Probability distributions	Unit
	Min (2.5% quantile) Mode value Median Max (97.5% quantile)	green curves results for 2014 red curves results for 2020	mass/mass
Sediments (sea water)			
Min (2.5% quantile)	24.626	51.416	
Mode value	42.159	88.025	
Median	47.377	98.918	
Max (97.5% quantile)	83.047	173.395	
Sediments (fresh water)			
	43.371	90.554	
	*	*	
	883.657	1844.999	
	2091.273	4366.394	

*inconclusive, bipolar (or pluripolar) or insignifant difference to median

3.8 Nano-CeO₂

TABLES 37-42.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR NANO-CeO₂ DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

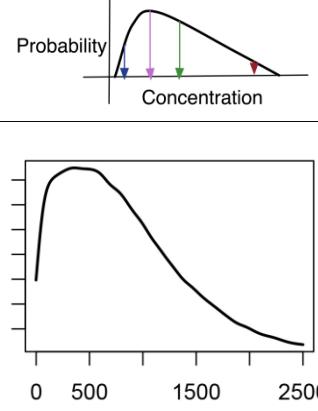
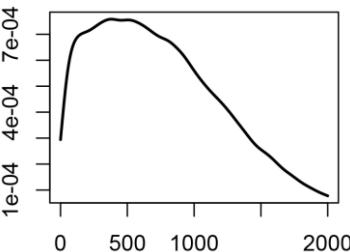
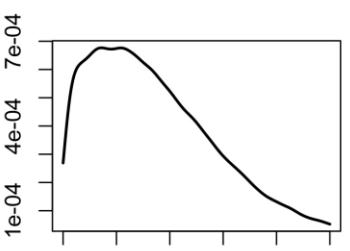
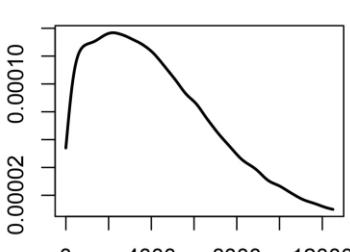
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sewage treatment sludge	44.130 352.327 699.365 2307.779		$\mu\text{g}/\text{kg}$
Waste mass incinerated	21.035 178.585 327.429 930.865		$\mu\text{g}/\text{kg}$
Bottom ash of waste incineration	49.665 359.009 778.315 2461.963		$\mu\text{g}/\text{kg}$
Fly ash of waste incineration	243.265 2198.434 3870.521 12259.710		$\mu\text{g}/\text{kg}$

TABLE 38.

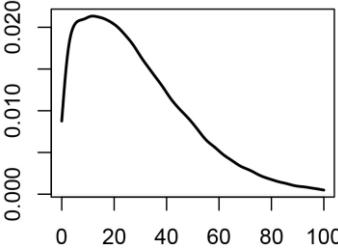
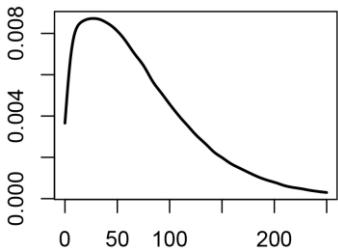
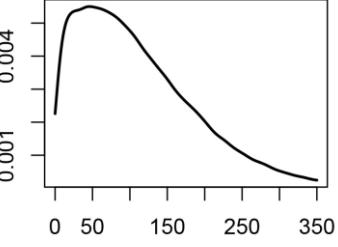
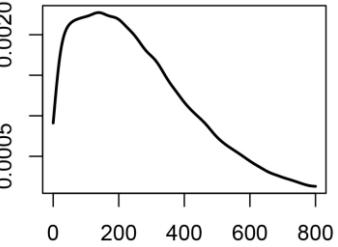
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Agricultural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	1.537 11.745 24.603 81.554	 <p>A graph showing the probability distribution of concentrations for agricultural soils. The x-axis is labeled 'Concentration' and ranges from 0 to 100. The y-axis is labeled 'Probability' and ranges from 0.0000 to 0.0200. The distribution is skewed to the right, peaking around 15-20.</p>	annual accumulation ng/kg
Natural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	3.724 26.851 60.331 223.900	 <p>A graph showing the probability distribution of concentrations for natural soils. The x-axis is labeled 'Concentration' and ranges from 0 to 200. The y-axis is labeled 'Probability' and ranges from 0.0000 to 0.0080. The distribution is skewed to the right, peaking around 50-75.</p>	annual accumulation ng/kg
Urban soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	5.964 45.571 95.459 316.429	 <p>A graph showing the probability distribution of concentrations for urban soils. The x-axis is labeled 'Concentration' and ranges from 0 to 350. The y-axis is labeled 'Probability' and ranges from 0.0001 to 0.004. The distribution is skewed to the right, peaking around 50-75.</p>	annual accumulation ng/kg
Sludge treated soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	14.519 138.373 231.661 780.536	 <p>A graph showing the probability distribution of concentrations for sludge treated soils. The x-axis is labeled 'Concentration' and ranges from 0 to 800. The y-axis is labeled 'Probability' and ranges from 0.00005 to 0.0020. The distribution is skewed to the right, peaking around 100-200.</p>	annual accumulation ng/kg

TABLE 39.

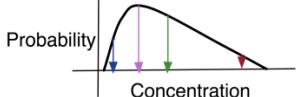
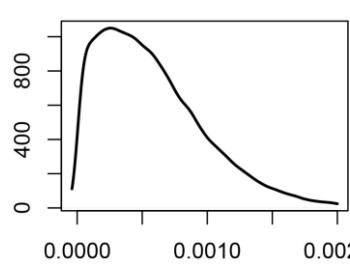
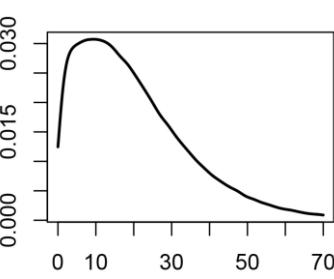
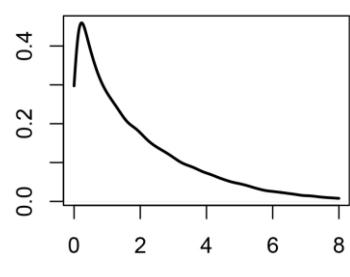
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Surface water (fresh water)	Min (2.5% quantile) 0.001 Mode value 0.004 Median 0.024 Max (97.5% quantile) 0.122		ng/l
Sea water	3.15E-05 2.62E-04 5.04E-04 0.002		ng/l
Sewage treatment effluent	1.069 9.323 17.101 59.631		ng/l
Sediments (fresh water)	0.033 0.240 1.341 6.871		annual accumulation μg/kg

TABLE 40.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Sediments (sea water)	Min (2.5% quantile) 0.006 Mode value 0.049 Median 0.094 Max (97.5% quantile) 0.302		annual accumulation μg/kg
Air	0.010 0.081 0.172 0.595		ng/m³

TABLE 41.

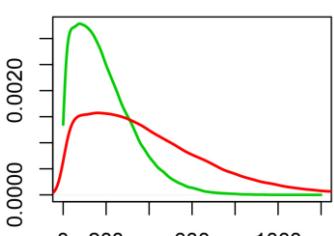
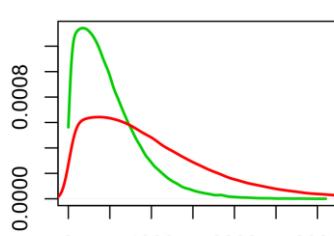
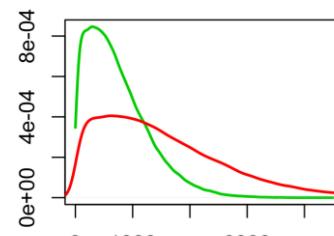
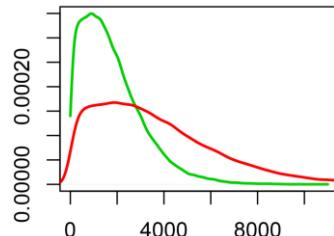
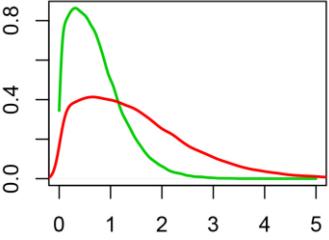
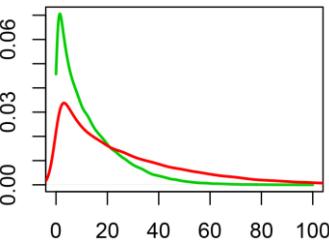
Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Agricultural soils			
Min (2.5% quantile)	9.991 20.859		ng/kg
Mode value	76.343 159.397		
Median	159.918 333.894		
Max (97.5% quantile)	530.100 1106.802		
Natural soils			
	24.205 50.537		ng/kg
	174.535 364.413		
	392.150 818.775		
	1455.350 3038.643		
Urban soils			
	38.763 80.934		ng/kg
	296.210 618.460		
	620.480 1295.508		
	2056.787 4294.391		
Sludge treated soils			
	94.370 197.037		ng/kg
	899.426 1877.923		
	1505.794 3143.966		
	5073.482 10592.980		

TABLE 42.

Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Sediments (sea water)			
Min (2.5% quantile)	0.038 0.080		
Mode value	0.318 0.665		
Median	0.613 1.281		
Max (97.5% quantile)	1.961 4.094		µg/kg
Sediments (fresh water)			
	0.212 0.443		
	1.558 3.254		
	8.719 18.204		
	44.659 93.243		µg/kg

3.9 Quantum dots

TABLES 43-47.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR QUANTUM DOTS (QD) DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

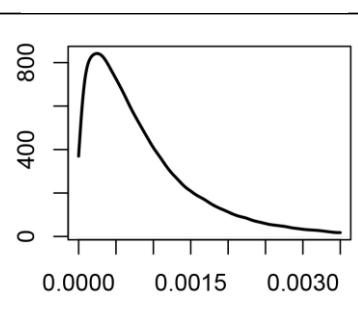
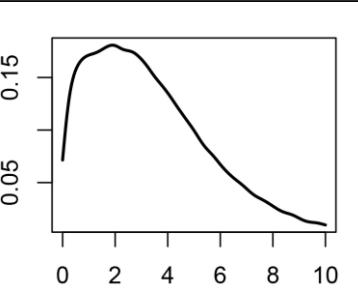
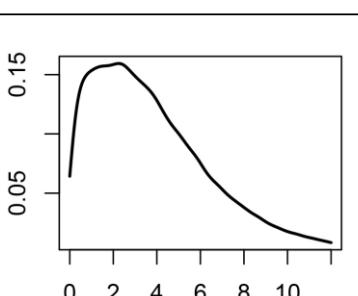
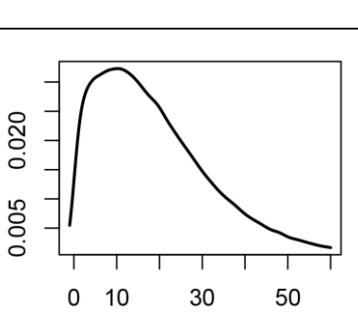
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sewage treatment sludge	Min (2.5% quantile) 3.58E-05 Mode value 0.000 Median 0.001 Max (97.5% quantile) 0.003	 <p>A probability distribution graph for sewage treatment sludge. The x-axis is labeled 'Concentration' and ranges from 0.0000 to 0.0030. The y-axis is labeled 'Probability' and ranges from 0 to 800. The distribution is unimodal and symmetric, peaking at a concentration of 0.001.</p>	$\mu\text{g}/\text{kg}$
Waste mass incinerated	0.084 0.887 1.387 4.364	 <p>A probability distribution graph for waste mass incinerated. The x-axis ranges from 0 to 10. The y-axis ranges from 0 to 0.15. The distribution is unimodal and symmetric, peaking at a concentration of 1.387.</p>	$\mu\text{g}/\text{kg}$
Bottom ash of waste incineration	0.198 2.244 3.312 11.392	 <p>A probability distribution graph for bottom ash of waste incineration. The x-axis ranges from 0 to 10. The y-axis ranges from 0 to 0.15. The distribution is unimodal and symmetric, peaking at a concentration of 3.312.</p>	$\mu\text{g}/\text{kg}$
Fly ash of waste incineration	0.980 10.251 16.448 56.697	 <p>A probability distribution graph for fly ash of waste incineration. The x-axis ranges from 0 to 50. The y-axis ranges from 0 to 0.020. The distribution is unimodal and symmetric, peaking at a concentration of 10.251.</p>	$\mu\text{g}/\text{kg}$

TABLE 44.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Sewage treatment effluent	Min (2.5% quantile) 0.000 Mode value 0.000 Median 0.000 Max (97.5% quantile) 0.001		ng/l
Sludge treated soils	0.010 0.069 0.190 0.962		annual accumulation pg/kg

TABLE 45.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Sediments (sea water)	4.71E-09 2.91E-08 9.74E+00 5.98E-07		$\mu\text{g}/\text{kg}$
Sediments (fresh water)	2.54E-08 3.21E-07 1.32E-06 1.17E-05		$\mu\text{g}/\text{kg}$

TABLE 46.

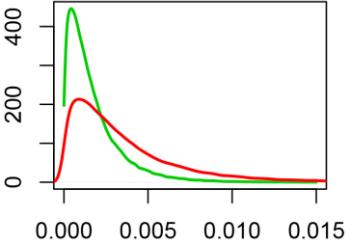
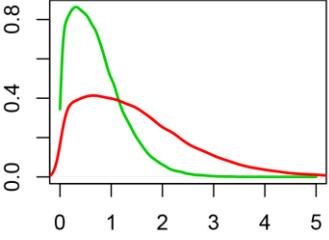
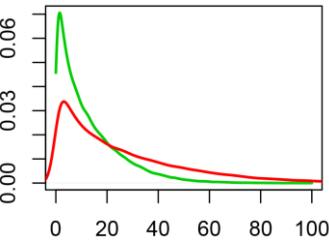
Concentrations	Statistical values	Probability distributions	Unit
	Min (2.5% quantile) Mode value Median Max (97.5% quantile)	green curves results for 2014 red curves results for 2020	mass/mass
Sludge treated soils			
Min (2.5% quantile)	6.7E-05	1.4E-04	
Mode value	4.5E-04	9.3E-04	
Median	0.001	0.003	
Max (97.5% quantile)	0.006	0.013	
			ng/kg

TABLE 47.

Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions green curves results for 2014 red curves results for 2020	Unit mass/mass
Sediments (sea water)			
Min (2.5% quantile)	0.038 0.080		
Mode value	0.318 0.665		
Median	0.613 1.281		
Max (97.5% quantile)	1.961 4.094		µg/kg
Sediments (fresh water)			
	0.212 0.443		
	1.558 3.254		
	8.719 18.204		
	44.659 93.243		µg/kg

3.10 Carbon black

TABLES 48-53.

PREDICTED ENVIRONMENTAL CONCENTRATIONS (PEC) IN THE FORM OF PROBABILITY (DENSITY) DISTRIBUTIONS FOR CARBON BLACK (CB) DERIVED FROM COMPUTER BASED STOCHASTIC SIMULATIONS ON NANOMATERIAL RELEASE TO AND SCENARIOS FOR FATE/RESIDENCE TIME IN TECHNICAL AND NATURAL COMPARTMENTS.

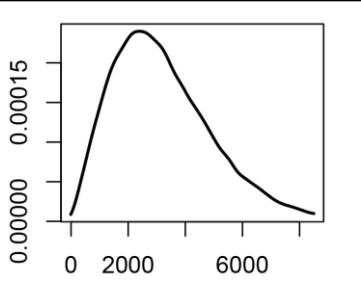
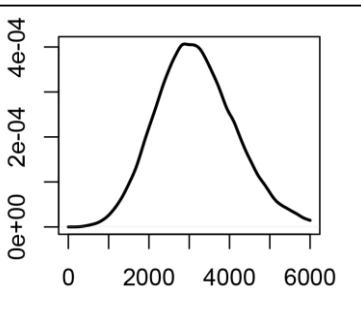
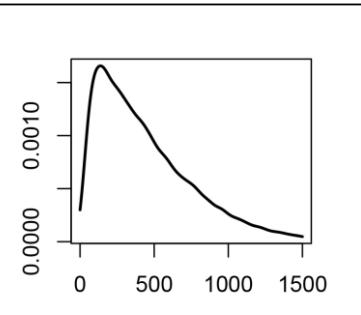
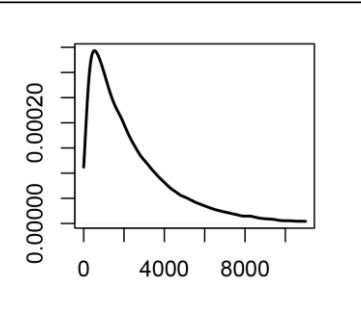
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Sewage treatment sludge	Min (2.5% quantile) 581.973 Mode value 2454.767 Median 2966.833 Max (97.5% quantile) 7684.489		mg/kg
Waste mass incinerated	659.115 1417.613 1470.559 2522.646		mg/kg
Bottom ash of waste incineration	43.804 140.195 365.275 1314.151		mg/kg
Fly ash of waste incineration	145.822 539.340 1749.621 8629.946		mg/kg

TABLE 49.

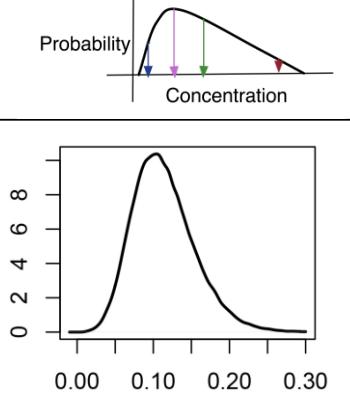
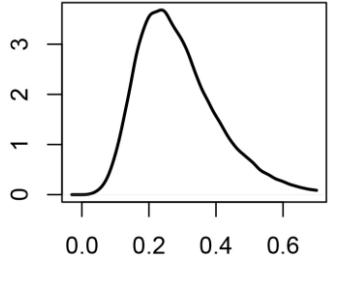
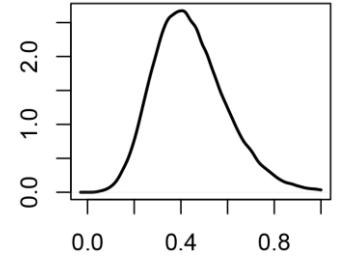
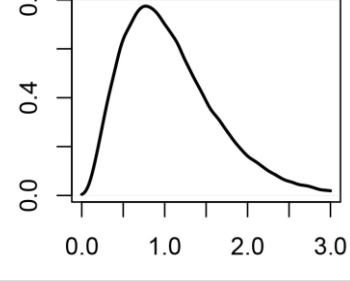
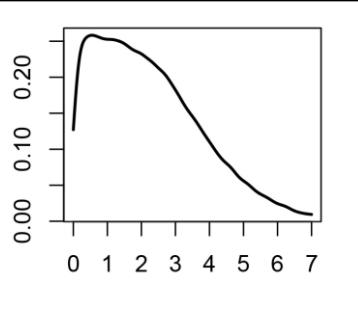
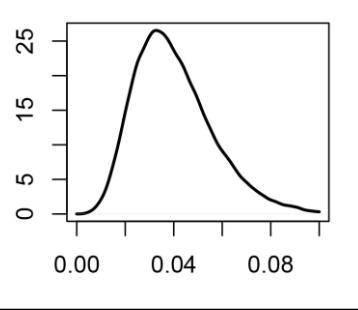
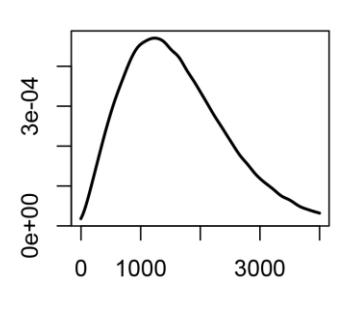
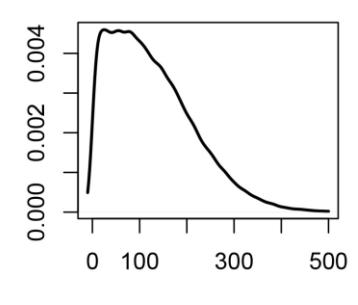
Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Agricultural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.047 0.103 0.109 0.206		annual accumulation mg/kg
Natural soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.106 0.232 0.269 0.593		annual accumulation mg/kg
Urban soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.182 0.400 0.424 0.800		annual accumulation mg/kg
Sludge treated soils Min (2.5% quantile) Mode value Median Max (97.5% quantile)	0.249 0.773 0.979 2.559		annual accumulation mg/kg

TABLE 50.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions	Unit mass/volume or mass/mass
Surface water (fresh water)	0.094 0.530 1.981 5.976	 <p>A probability distribution plot showing the relationship between concentration and probability. The x-axis is labeled 'Concentration' and ranges from 0 to 7. The y-axis is labeled 'Probability' and ranges from 0.00 to 0.20. The distribution is skewed to the right, with the highest probability occurring at a low concentration (around 1.5).</p>	$\mu\text{g/l}$
Sea water	0.015 0.034 0.038 0.080	 <p>A probability distribution plot showing the relationship between concentration and probability. The x-axis is labeled 'Concentration' and ranges from 0.00 to 0.08. The y-axis ranges from 0 to 25. The distribution is symmetric and bell-shaped, peaking at approximately 0.03.</p>	$\mu\text{g/l}$
Sewage treatment effluent	291.850 1241.262 1504.751 3896.095	 <p>A probability distribution plot showing the relationship between concentration and probability. The x-axis is labeled 'Concentration' and ranges from 0 to 3000. The y-axis is labeled '0e+00' and '3e-04'. The distribution is highly right-skewed, with the highest probability occurring at a low concentration (around 1000).</p>	$\mu\text{g/l}$
Sediments (fresh water)	5.530 * 112.224 335.783	 <p>A probability distribution plot showing the relationship between concentration and probability. The x-axis is labeled 'Concentration' and ranges from 0 to 500. The y-axis ranges from 0.0000 to 0.0004. The distribution is right-skewed, with the highest probability occurring at a low concentration (around 50).</p>	annual accumulation mg/kg

*inconclusive, bipolar (or pluripolar) or insignifant difference to median

TABLE 51.

Concentrations in environmental or technical compartments	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions 	Unit mass/volume or mass/mass
Sediments (sea water)	Min (2.5% quantile) 2.783 Mode value 6.278 Median 7.092 Max (97.5% quantile) 14.933		annual accumulation mg/kg
Air	0.073 0.157 0.176 0.341		μg/m³

TABLE 52.

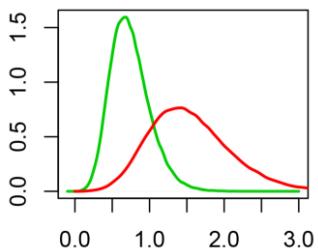
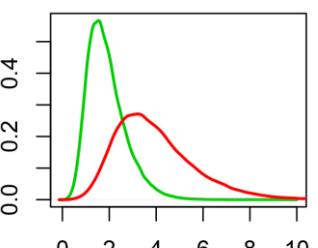
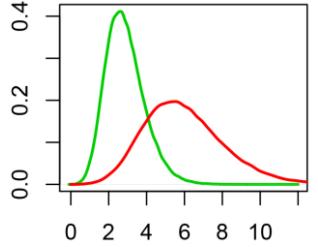
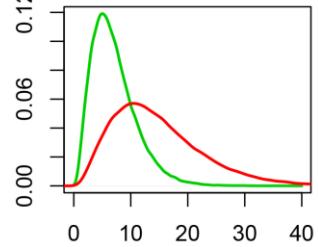
Concentrations	Statistical values Min (2.5% quantile) Mode value Median Max (97.5% quantile)	Probability distributions <small>green curves results for 2014 red curves results for 2020</small>	Unit mass/mass
Agricultural soils			
Min (2.5% quantile)	0.305 0.637		mg/kg
Mode value	0.670 1.398		
Median	0.711 1.484		
Max (97.5% quantile)	1.340 2.798		
Natural soils			
	0.692 1.444		mg/kg
	1.510 3.152		
	1.747 3.647		
	3.857 8.053		
Urban soils			
	1.183 2.471		mg/kg
	2.599 5.426		
	2.759 5.760		
	5.199 10.855		
Sludge treated soils			
	1.621 3.385		mg/kg
	5.025 10.492		
	6.364 13.287		
	16.632 34.726		

TABLE 53.

Concentrations	Statistical values	Probability distributions green curves results for 2014 red curves results for 2020	Unit
	Min (2.5% quantile) Mode value Median Max (97.5% quantile)		mass/mass
Sediments (sea water)			
Min (2.5% quantile)	18.087	37.764	
Mode value	40.806	85.199	
Median	46.100	96.252	
Max (97.5% quantile)	97.065	202.663	
Sediments (fresh water)			
	35.948	75.056	
	*	*	
	729.453	1523.034	
	2182.592	4557.059	

*inconclusive, bipolar or pluripolar) or insignificant difference to median

Nanomaterials in the Danish environment

The report is Annex 2 to the report ""Nanomaterials in the Danish environment. Modelling exposure of the Danish environment to selected nanomaterials".



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