NanoFATE Deliverable 6.7

Report on ENP risk assessment in the different usage scenarios; this will include gap analysis, critical appraisal of available hazard and exposure assessment methodologies and the identification of vulnerable species and environmental compartments

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Research Report Summary

River concentration, river sediment loading and soil concentrations have been predicted for the rivers and soils of Europe for nanosilver and nano ZnO. In contrast to the previous deliverable D6.6, new slightly higher loading rates were used. Fate data used in the modelling drew on both NanoFate WP2 and literature data. For the purposes of risk assessment new lower PNECs were used mainly based on NanoFate data. The spatio-temporal variability of concentrations in surface waters and soils across Europe was modelled using the model GWAVA usage population and sewage effluent discharge point maps. Loading of nano Ag and nano ZnO from sewage to rivers was modelled by accounting for connectivity to sewerage and sewage treatment efficiency. The resulting nano Ag and nano ZnO concentrations in rivers were modelled by considering the effect of dilution, water abstraction, residence time, and particle settling. Temporal variability in particle concentrations as caused by temporal climate variation was simulated using climate data for the 1979-2000 period. Model scenarios compared the influence of different reported sewage removal rates. Although no data are presently available for toxicity to river benthic invertebrates, predictions were also made for nanoparticle accumulation in river bed sediments.

For the expected scenario concentrations of around 20 ng/L nanosilver and 5,000 ng/L nano ZnO in sewage effluent were predicted (assuming 200 L/cap/d wastewater). Therefore, nanosilver in effluent would exceed a 10 ng/L Ag ion PNEC but be below a nanosilver 28 ng/L PNEC. Nano ZnO in effluent would exceed the 2,194 ng/L nano ZnO PNEC. For Europe around 50% of rivers would be predicted to have nanosilver concentrations of 0.0001 ng/L or

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less and 95% of rivers have 0.1 ng/L or less of nanosilver. Thus, most European rivers would have nanosilver levels 2-orders of magnitude below the PNEC. For Europe around 50% of rivers would be predicted to have nano ZnO concentrations of 1 ng/L or less and 95% of rivers have 500 ng/L or less of nano ZnO. This is only a factor 5 below the PNEC.

This analysis puts nano ZnO as being of greater concern to the aquatic environment than nanosilver. This is because of the apparent much higher use of nano ZnO and in this simulation the particularly high water column settlement rate chosen for nanosilver.

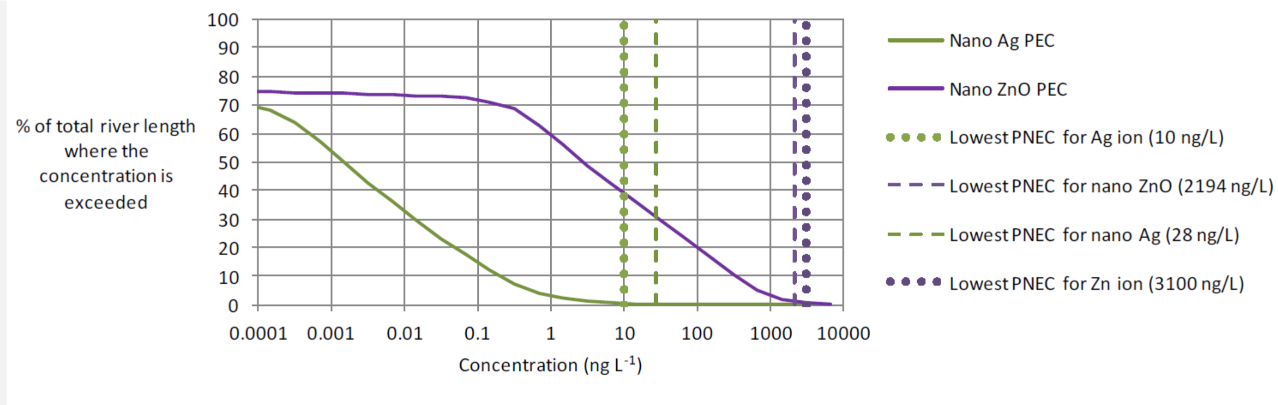

Figure 4. Cumulative frequency distribution for each nanoparticle for the worst-case scenario (90th percentile PECs), including the lowest PNEC for each nanoparticle and ion.

Soil concentrations for agricultural land were predicted for countries across Europe based on national sludge disposal practices and their populations. A second method was used based on soil nitrogen fertilisation recommendations. The soil predictions assumed all the nano Ag and nano ZnO removed from sewage effluent were available for application to agricultural land via sewage sludge. Model scenarios compared different transfer rates to sewage sludge, different proportions of land receiving the national sludge (1 or 57%) and different soil ploughing (mixing) depths of 12 cm and 25 cm. The highest predicted soil value (assuming 3 applications spread over 12 years) for nano Ag was 8.8 µg/kg dry weight for agricultural soils whilst the lowest value for nano Ag toxicity was 4.8 mg/kg. However, if a 1000x safety factor is invoked to derive a PNEC of 4.8 µg/kg then we would exceed this. Similarly, the highest nano ZnO soil concentration was 939 µg/kg dry whilst the most conservative value for nano ZnO toxicity was 119 mg/kg. However, if a 1000x safety factor is invoked to derive a PNEC of 120 µg/kg then we would exceed this.

Uncertainties remain over the true consumption and discharge of nanoparticles in Europe. More information on the fate of nanoparticles in the river environment, particularly the speed at which they settle is needed. There are still too few studies on the toxicity of nanoparticles

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to different soil species to give confidence in soil risk assessment. More effort is needed to consider the influence of environmental transformations of nanoparticles, such as sulphide coatings on their toxicity.

In water bacteria and planktivores appear the most sensitive to nanosilver, whilst for nano ZnO the most sensitive species were algae and planktivores.

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