**Table S1 Commonly used standard test methods for water and soil toxicity**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **No.** | **test organism** | **species** | **endpoint** | **exposure duration** | **applicable medium** | **standard title and number** |
| 1 | luminescent bacteria | *Vibrio fischeri* | luminescence | 5, 15 or 30min | water, sediment or other solids | Water Quality-Determination of the Inhibitory Effect of Water Samples on the Light Emission of Vibrio fischeri (Luminescent Bacteria Test) (ISO 11348); Water Quality-Kinetic Determination of the Inhibitory Effect of Sediment, other Solids and Coloured Samples on the Light Emission of Vibrio fischeri (Kinetic Luminescent Bacteria Test) (ISO 21338) |
| 2 | luminescent bacteria | *Photobacterium phosphoreum* | luminescence | 15 min | water | Water Quality-Determination of the Acute Toxicity-Luminescent Bacteria Test (GB/T 15441) |
| 3 | algae | various recommended species | growth | usually 72 hours | water | Water Quality-Fresh Water Algal Growth Inhibition Test with Unicellular Green Algae (ISO 8692);Freshwater Alga and Cyanobacteria, Growth Inhibition Test (OECD Test No.201);Chemicals-Alga Growth Inhibition Test (GB/T 21805);Test Guidelines on Environmental Safety Assessment for Chemical Pesticides-Part 14: Alga Growth Inhibition Test (GB/T 31270.14);Ecological Effects Test Guidelines — Algal Toxicity (EPA OCSPP 850.4500) |
| 4 | water flea | *Daphnia magna* | mobility | 48 h | water | Water Quality-Determination of the Inhibition of the Mobility of *Daphnia magna* Straus-Acute Toxicity Test (ISO 6341);*Daphnia* sp.Acute Immobilisation Test (OECD Test No.202);Chemicals-*Daphnia* sp. Acute Immobilisation Reproduction Test (GB/T 21830);Test Guidelines on Environmental Safety Assessment for Chemical Pesticides-Part 13: *Daphina* sp. Acute Immobolisation Test (GB/T 31270.13);Water Quality-Determination of the Acute Toxicity of Substance to *Daphnia* (*Daphnia magna* Straus) (GB/T 13266) |
| 5 | water flea | *Daphnia magna* | survival, reproduction | 21 d | water | Water Quality-Determination of long term toxicity of substances to *Daphnia magna* Straus (ISO 10706);*Daphnia magna* Reproduction Test (OECD Test No.211);Chemicals-*Daphnia magna* Reproduction Test (GB/T 21828) |
| 6 | water flea | *Ceriodaphnia dubia* | survival, reproduction | 6~8 d | water | Water Quality-Determination of Chronic Toxicity to *Ceriodaphnia dubia* (ISO 20665) |
| 7 | fish | zebrafish (*Danio rerio*) | observations on the embryo: number of coagulated eggs, tail detachment, Heartbeat | 48 h | water | Water Quality-Determination of the acute toxicity of waste water to zebrafish eggs (Danio rerio) (ISO 15088) |
| 8 | fish | zebrafish (*Danio rerio*) | observations on the embryo: coagulation of embryos, lack of somite formation, non-detachment of the tail, and lack of heartbeat | 24~96 h | water | Fish Embryo Acute Toxicity (FET) (OECD Test No. 236) |
| 9 | plant | winter barley (*Hordeum vulgare L.*), oat (*Avena sativa L.*), wheat (*Triticum aestivum L.*) | root elongation | 4 days | soil | Soil Quality-Determination of the Effects of Pollutants on Soil Flora-Part 1: Method for the Measurement of Inhibition of Root Growth (ISO 11269-1) |
| 10 | plant | lettuce (*Lactuca sativa L.*) | emergence | usually 5 days | soil | Soil Quality-Determination of the Effects of Pollutants on Soil Flora-Screening Test for Emergence of Lettuce Seedlings (Lactuca sativa L.) (ISO 17126) |
| 11 | plant | various recommended species | emergence, growth | 14~21 days | soil | Soil Quality-Determination of the Effects of Pollutants on Soil Flora-Part 2: Effects of Contaminated Soil on the Emergence and Early Growth of Higher Plants (ISO 11269-2);Terrestrial Plant Test: Seedling Emergence and Seeding Growth Test (OECD Test No.208);Seedling Emergence and Seeding Growth (EPA OCSPP 850.4100); Test Guidelines on Environmental Safety Assessment for Chemical Pesticides-Part 19: Effects on Non-Target Plants (GB/T 31270.19) |
| 12 | plant | various recommended species | growth | 21~28 days | soil | Terrestrial Plant Test: Vegetative Vigour Test (OECD Test No. 227);Chemicals-Terrestrial Plant Test-Vegetative Vigour Test (GB/T 27851);Terrestrial Plant Toxicity, Tier I (Vegetative Vigor) (EPA OCSPP 850.4150) |
| 13 | plant | turnip rape (Brassica rapa), oats (Avena sativa) | emergrnce, growth, reproduction | 5~8 weeks | soil | Soil Quality-Biological Methods-Chronic Toxicity in Higher Plants (ISO 22030) |
| 14 | plant | Broad beans (*Vicia faba*) | Micronucleus frqueney | 48 h for water, and 3~5 days for soil | soil or water | Soil Quality-Assessment of Genotoxic Effects on Higher Plants-Vicia Faba Micronucleus Test (ISO 29200) |
| 15 | terrestrial invertebrates | earthworms (Eisenia fetida, Eisenia andrei) | survival | 14 days | soil | Soil Quality-Effects of Pollutants on Earthworms-Part 1:Determination of Acute Toxicity to *Eisenia fetida/Eisenia andrei* (ISO 11268-1)；Earthworm, Acute Toxicity Tests (OECD Test No. 207);Chemical-Test Method of Earthworm Acute Toxicity Test (GB/T 21809);Test Guidelines on Environmental Safety Assessment for Chemical Pesticides-Part 15: Earthworm Acute Toxicity Test (GBT 31270.15) |
| 16 | terrestrial invertebrates | earthworms (Eisenia fetida, Eisenia andrei) | survival, growth, reproduction | 56 days | soil | Soil Quality-Effects of Pollutants on Earthworms-Part 2:Determination of Effects on Reproduction of *Eisenia fetida/Eisenia andrei*(ISO 11268-2); Earthworm Reproduction Test (*Eisenia fetida/Eisenia andrei*) (OECD 222) |
| 17 | terrestrial invertebrates | earthworms (Eisenia fetida, Eisenia andrei) | survival, growth | 28 days | soil | Earthworm Subcheonic Toxicity Test (EPA OCSPP 850.3100) |
| 18 | terrestrial invertebrates | earthworms (Eisenia fetida, Eisenia andrei) | avoidance | 2 days | soil | Soil Quality-Avoidance Test for Determining the Quality of Soils and Effects of Chemicals on Behaviour-Part 1: Test with Earthworms (Eisenia fetida and Eisenia andrei) (ISO 17512-1) |
| 19 | terrestrial invertebrates | collembola (Folsomia candida) | survival, reproduction | 28 days | soil | Soil Quality-Inhibition of Reproduction of Collembola (*Folsomia candida*) by Soil Contaminants (ISO 11267);Collembolan Reproduction Test in Soil (OECD 232) |
| 20 | terrestrial invertebrates | collembola (Folsomia candida) | avoidance | 2 days | soil | Soil Quality-Avoidance Test for Determining the Quality of Soils and Effects of Chemicals on Behaviour-Part 2: Test with Collembolans (*Folsomia Candida*) (ISO 17512-2) |
| 21 | terrestrial invertebrates | enchytraeids (Enchytraeus albidus) | survival, reproduction | 42 days | soil | Soil Quality-Effects of Contaminants on *Enchytraeidae* (*Enchytraeus* sp.)-Determination of Effects on Reproduction (ISO 16387);Enchytraeid Reproduction Test (OECD 220) |
| 22 | terrestrial invertebrates | nematodes (Caenorhabditis elegans) | growth, fertility, reproduction | 4 days | soil or water | Water Quality-Determination of Toxic Effect of Sediment and Soil Samples on Growth, Fertility and Reproduction of *Caenorhabditis elegans(*ISO 10872) |
| 23 | microorganisms | Arthoacter sobioms | dehydrogenase activity | usally 3 hours | mixture of soil and inoculum | Soil Quality-Contact Test for Solid Samples Using the Dehydrogenase Activity of *Arthrobacter globiformis*(ISO 18187) |
| 24 | microorganisms | microbial community | ammonium oxidation | 6 h | slurry formed by soil and test solution | Soil Quality-Determination of Potential Nitrification and Inhibition of Nitrification-Rapid Test by Ammonium Oxidation(ISO 15685) |
| 25 | microorganisms | microbial community | nitrogen transformation | 28 days | soil | Soil Quality-Biological Methods-Determination of Nitrogen Mineralization and Nitrification in Soils and the Influence of Chemicals on these Processes (ISO 14238) |
| 26 | microorganisms | microbial community | respiration | 28~100 days | soil | Soil Microorganisms: Carbon Transformation Test (OECD 217);Chemicals-soil Microorganisms-Carbon Transformation Test (GB/T 27855) |
| 27 | microorganisms | microbial community | respiration | usally 5 days | soil | Soil Quality-Determination of Abundance and Activity of Soil Microflora Using Respiration Curves (ISO 17155) |
| 28 | microorganisms | microbial community | respiration, nitrogen transformation | 28~100 days | soil | Test Guidelines on Environmental Safety Assessment for Chemical Pesticides-Part 16: Soil Microorganism Toxicity Test (GB/T 31270.16) |

Table S2. Main oxidation products of organophosphorus pesticide and their acute toxicities calculated with T.E.S.T. (version 5.1)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Type** | **Original pesticide** | ***LC*50 to *Daphnia magna* (mg/L)** | **Oral *LC*50 to rat (mg/kg)** | **Structure of the main products** | ***LC*50 to *Daphnia magna* (mg/L)** | **Oral *LC*50 to rat (mg/kg)** | **oxidant** | **reference** |
| 1 | Phosphorothioates | salithion | 1.24×10-2 | 77.86 | salioxon | 7.7×10-2 | 103.82 | ozone | [1] |
| 2 |  | cyanophos (CYAP) | 3.10×10-3 | 252.86 | CYAP oxon | 1.38×10-2 | N/A | ozone | [1] |
| 3 |  | chlorpyrifos-methyl | 5.46×10-3 | 501.60 | chlorpyrifos-methyl oxon | 1.96×10-2 | 391.09 | ozone | [1] |
| 4 |  | tolclofos-methyl | 4.15×10-3 | 839.26 | tolclofos-methyl oxon | 1.71×10-2 | 568.22 | ozone | [1] |
| 5 |  | fenitrothion (MEP) | 3.97×10-3 | 31.09 | MEP oxon | 8.11×10-2 | 11.03 | ozone | [1] |
| 6 |  | fenthion (MPP) | 4.76×10-2\* | 189.87\* |  | 3.88×10-2 | 7.66 | ozone | [1] |
|  |  |  |  |  |  | 0.40 | 2.61 | ozone | [1] |
|  |  |  |  |  |  | 0.15 | 8.59 | ozone | [1] |
|  |  |  |  |  |  | 4.34×10-2 | 163.99 | ozone | [1] |
| 7 |  | chlorpyrifos | 2.91×10-3 | 106.77 | chlorpyrifos oxon | 2.43×10-2 | 525.92 | ozone;ultrasonic | [1, 2] |
|  |  |  |  |  |  | 1.82 | 109.47 | ultrasonic | [2] |
| 8 |  | diazinon | 1.86×10-3 | 178.32 | diazinon oxon | 1.22×10-2 | 348.58 | ozone;ultrasonic | [1, 2] |
|  |  |  |  |  |  | 0.51 | 771.46 | ozone | [1] |
|  |  |  |  |  |  | 12.38 | 223.55 | ozone;ultrasonic | [1, 2] |
|  |  |  |  |  |  | 9.21×10-3 | 438.53 | ultrasonic | [2] |
|  |  |  |  |  |  | 1.46×10-2 | 559.75 | ultrasonic | [2] |
|  |  |  |  |  |  | 5.20×10-2 | 385.64 | ultrasonic | [2] |
| 9 |  | isoxathion | 1.47×10-3 | 251.48 | isoxathion oxon | 1.50×10-2 | N/A | ozone | [1] |
| 10 | Phosphorodithioates | malathion | 8.50×10-3 | 345.83 | malathion oxon | 2.86×10-2 | 148.05 | Fenton-based processes | [3] |
|  |  |  |  |  |  | 87.38 | 2200.11 | Fenton-based processes | [3] |
|  |  |  |  |  |  | 138.01 | 10689.86 | Fenton-based processes | [3] |
|  |  |  |  |  |  | 248.60 | 9357.33 | Fenton-based processes | [3] |
|  |  |  |  |  |  | 562.91 | 2822.43 | Fenton-based processes | [3] |
| 11 |  | methidathion (DMTP) | 2.92×10-2 | 60.89 | DMTP oxon | 0.24 | 60.46 | ozone | [1] |
| 12 |  | phenthoate (PAP) | 3.20×10-3 | 65.50 | PAP oxon | 1.25×10-2 | 330.74 | ozone | [1] |
| 13 |  | ethion | 1.41×10-4 | 29.02 | ethion oxon | 0.33×10-3 | 14.95 | ozone | [1] |
|  |  |  |  |  |  | 1.15×10-3 | 17.17 | ozone | [1] |
| 14 |  | phosmet (PMP) | 5.31×10-2 | 42.84 | PMP oxon | 0.41 | 33.90 | ozone | [1] |
| 15 | Phosphonothioates | EPN | 9.55×10-3 | 24.16 | EPN oxon | 1.95×10-2 | 16.65 | ozone | [1] |
| 16 |  | cyanofenphos (CYP) | 4.39×10-3 | 16.10 | CYP oxon | 1.97×10-2 | 25.85 | ozone | [1] |
| 17 | others | edifenphos | 1.65×10-2 | 228.68 |  | N/A | 253.08 | ozone | [1] |
|  |  |  |  |  |  | 0.41 | 887.61 | ozone | [1] |
| 18 |  | isofenphos | 1.02×10-2 | 21.10\* | Isofenphos oxon | 7.43×10-2 | N/A | ozone | [1] |
| 19 |  | butamifos | 5.02×10-3 | 403.09 | butamifos oxon | 1.01×10-2 | 431.93 | ozone | [1] |

\*The predicted value is failed to obtain from the consensus method, and the data come from US EPA ECOTOX database.

**References:**

[1]. Ohashi, N., et al., Ozonation products of organophosphorous pesticides in water. Eisei kagaku, 1994. 40(2): p. 185-192.

[2]. Zhang, Y., et al., The degradation of chlorpyrifos and diazinon in aqueous solution by ultrasonic irradiation: Effect of parameters and degradation pathway. Chemosphere, 2011. 82(8): p. 1109-1115.

[3]. Vasseghian, Y., et al., Decontamination of toxic Malathion pesticide in aqueous solutions by Fenton-based processes: Degradation pathway, toxicity assessment and health risk assessment. Journal of Hazardous Materials, 2022. 423: p. 127016.