# 典型酰胺类除草剂的水生生物水质基准

赵 晋1，樊怡利1，张瑞卿1,\*，李会仙2,#，蔡 婷3

1. 内蒙古大学生态与环境学院，呼和浩特 010021；
2. 中国环境科学研究院 环境基准与风险评估国家重点实验室，北京 100012
3. 内蒙古自治区农牧业技术推广中心，呼和浩特 010010

表S1 酰胺类农药的急性和慢性毒性数据

Table S1 Acute and chronic toxicity data of amide pesticides

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 物种Species | 拉丁名Latin name | 效应Effect | 效应终点Effect endpoint | 暴露时间（d）Exposure time（d） | 毒性值（mg·L−1）Toxicity value（mg·L−1） | 最终毒性值Final toxicity value | 成分Ingredient | 可靠度Reliability | 参考文献References |
| 甲草胺急性毒性 Alachlor acute toxicity | | | | | | | | | |
| 美洲蟾蜍\* | *Bufo americanus* | 死亡Mortality | LC50 | 4 | 3.3 | 3.58748 | 43%乳油EC | 2 | [1] |
| 美洲蟾蜍\* | *Bufo americanus* | 死亡Mortality | LC50 | 4 | 3.9 | 2 | [1] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | LC50 | 2 | 7.9 | 10.651 | 99%原药TC | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | LC50 | 2 | 14.36 | 41.5%乳油EC | 1 | [3] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 1 | 18.6 | 18.6 | 40%乳油EC | 2 | [4] |
| 隆线溞 | *Cladoceran Daphnia carinata* | 死亡Mortality | LC50 | 2 | 11.1 | 11.1 | 99.2%原药TC | 2 | [5] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | EC50 | 4 | 9.45 | 5.2488 | 93%原药TC | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | LC50 | 4 | 1.9 | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 14.5 | 1 | [6] |
| 斑点叉尾鮰 | *Ictalurus punctatus* | 死亡Mortality | LC50 | 4 | 16.7 | 16.7 | 43%乳油EC | 2 | [1] |
| 豹蛙\* | *Rana pipiens* | 死亡Mortality | LC50 | 4 | 3.5 | 6.34429 | 43%乳油EC | 2 | [1] |
| 豹蛙\* | *Rana pipiens* | 死亡Mortality | LC50 | 4 | 11.5 | 2 | [1] |
| 虹鳟鱼 | *Oncorhynchus mykiss* | 死亡Mortality | LC50 | 4 | 9.1 | 9.1 | 99%原药TC | 2 | [2] |
| 黑头呆鱼\* | *Pimephales promelas* | 死亡Mortality | LC50 | 4 | 5 | 5 | 92.6%原药TC | 2 | [7] |
| 大菱鲆 | *Scophthalmus maximus* | 死亡Mortality | LC50 | 4 | 1.838 | 1.838 | 99.2%原药TC | 2 | [8] |
| 非洲爪蟾\* | *Xenopus laevis* | 死亡Mortality | LC50 | 4 | 6.1 | 6.1 | 99%原药TC | 2 | [9] |
| 甲草胺慢性毒性Alachlor chronic toxicity | | | | | | | | |  |
| 鲫鱼 | *Carassius auratus* | 形态Morphology | LOEL | 60 | 0.001 | 0.001 | 99%原药TC | 2 | [10] |
| 鲫鱼 | *Carassius auratus* | 激素 Hormone(s) | LOEL | 60 | 0.001 | 2 | [11] |
| 鲫鱼 | *Carassius auratus* | 酶 Enzyme(s) | LOEL | 60 | 0.001 | 2 | [10] |
| 金鱼藻 | *Ceratophyllum demersum* | 生长Growth | EC50 | 4 | 0.085 | 0.085 | 94.1%活性成分a.i. | 2 | [12] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | IC50 | 4 | 5.9 | 6.401848 | 99%原药TC | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 生长Growth | IC50 | 4 | 7.3 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 生长Growth | IC50 | 7 | 2.5 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | IC50 | 7 | 4.3 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | LOEC | 7 | 25 | 41.5%乳油EC | 1 | [3] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | LOEC | 7 | 25 | 1 | [3] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | MATC | 4 | 5.3 | 99%原药TC | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | MATC | 4 | 6.9 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | MATC | 7 | 2.8 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | MATC | 7 | 5.3 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | MATC | 7 | 17.68 | 41.5%乳油EC | 1 | [3] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | NOEC | 7 | 12.5 | 1 | [3] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | NOEC | 7 | 12.5 | 1 | [3] |
| 衣藻 | *Chlamydomonas* | 生长Growth | EC50 | 4 | 0.46 | 0.46 | 94.1%活性成分a.i. | 2 | [12] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 4 | 0.026 | 0.37935 | 99%原药TC | 2 | [2] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 4 | 5.54 | 40%乳油EC | 2 | [4] |
| 鲤鱼 | *Cyprinus carpio* | 细胞 Cell(s） | LOEL | 28 | 1 | 0.1 | 42% 活性成分a.i. | 2 | [13] |
| 鲤鱼 | *Cyprinus carpio* | 细胞 Cell(s） | LOEL | 28 | 0.1 | 2 | [13] |
| 鲤鱼 | *Cyprinus carpio* | 生理变化Biochemistry | LOEL | 28 | 0.1 | 2 | [13] |
| 鲤鱼 | *Cyprinus carpio* | 遗传Genetics | NOEC | 30 | 0.1 | 乳油EC | 2 | [14] |
| 鲤鱼 | *Cyprinus carpio* | 遗传Genetics | NOEC | 60 | 0.1 | 2 | [14] |
| 大型蚤 | *Daphnia magna* | 死亡Mortality | NOEL | 6 | 0.1 | 0.1 | 原药TC | 2 | [15] |
| 大型蚤 | *Daphnia magna* | 繁殖Reproduction | NOEL | 6 | 0.1 | 2 | [15] |
| 大型蚤 | *Daphnia magna* | 生长Growth | NOEL | 6 | 0.1 | 2 | [15] |
| 浮萍 | *Lemna* | 生长Growth | EC50 | 4 | 0.482 | 0.482 | 94.1%活性成分a.i. | 2 | [12] |
| 豹蛙\* | *Lithobates pipiens* | 生长Growth | NOEC | 46 | 0.00015 | 0.00015 | 97%原药TC | 2 | [16] |
| 豹蛙\* | *Lithobates pipiens* | 死亡Mortality | NOEC | 46 | 0.00015 | 2 | [16] |
| 茨藻 | *Najas* | 生长Growth | EC50 | 4 | 0.584 | 0.584 | 94.1%活性成分a.i. | 2 | [12] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | LOEC | 64 | 1.08 | 1.08 | 92.6%原药TC | 2 | [17] |
| 黑头呆鱼\* | *Pimephales promelas* | 死亡Mortality | MATC | 64 | 1.08 | 2 | [17] |
| 黑头呆鱼\* | *Pimephales promelas* | 发育Development | NOEC | 6 | 1.1 | 2 | [7] |
| 黑头呆鱼\* | *Pimephales promelas* | 死亡Mortality | NOEC | 6 | 1.1 | 2 | [7] |
| 黑头呆鱼\* | *Pimephales promelas* | 死亡Mortality | NOEC | 60 | 1.1 | 2 | [7] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | NOEC | 64 | 0.517 | 2 | [17] |
| 四尾栅藻 | *Scendesmus quadricauda* | 生长Growth | EC50 | 4 | 1.328 | 1.328 | 94.1%活性成分a.i. | 2 | [12] |
| 月牙藻 | *Selenastrum* | 生长Growth | EC50 | 4 | 0.01 | 0.01 | 94.1%活性成分a.i. | 2 | [12] |
| 剑水蚤 | *Tigriopus japonicus* | 繁殖Reproduction | NOEL | 14 | 0.1 | 0.1 | 99%原药TC | 2 | [17] |
| 剑水蚤 | *Tigriopus japonicus* | 发育Development | NOEL | 14 | 0.1 | 2 | [18] |
| 剑水蚤 | *Tigriopus japonicus* | 繁殖Reproduction | NOEL | 14 | 0.1 | 2 | [18] |
| 剑水蚤 | *Tigriopus japonicus* | 发育Development | NOEL | 14 | 0.1 | 2 | [18] |
| 乙草胺急性毒性Acetochlor acute toxicity | | | | | | | | | |
| 小球藻 | *Chlorella pyrenoidosa* | 酶 Enzyme(s) | EC50 | 1 | 0.1 | 0.1 | 95%原药TC | 2 | [19] |
| 隆线溞 | *Cladoceran Daphnia carinata* | 死亡Mortality | LC50 | 2 | 11.8 | 11.8 | 99.7%原药TC | 2 | [5] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | EC50 | 4 | 1.28 | 2.412 | 98%原药TC | 1 | [20] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | EC50 | 4 | 2.8 | 95%原药TC | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 0.703 | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 1.34 | 93%原药TC | 2 | [21] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 1.44 | 2 | [21] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 1.52 | 93.2%原药TC | 2 | [22] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 1.86 | 50%乳油EC | 2 | [23] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 2.9 | 98%原药TC | 1 | [20] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 2.9 | 93.2%原药TC | 1 | [24] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 3 | 93%原药TC | 2 | [21] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 3.04 | 93.2%原药TC | 2 | [25] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 4.45 | 95%原药TC | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 5.09 | 98%原药TC | 1 | [20] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 5.82 | 93%原药TC | 2 | [21] |
| 克氏原螯虾 | *Procambarus clarkii* | 死亡Mortality | LC50 | 2 | 0.1235 | 0.1235 | 50%乳油EC | 2 | [26] |
| 非洲爪蟾\* | *Xenopus laevis* | 死亡Mortality | LC50 | 4 | 3.03 | 3.03 | 92.3%原药TC | 2 | [27] |
| 热带爪蟾\* | *Xenopus tropicalis* | 死亡Mortality | LC50 | 4 | 2.42 | 2.42 | 2 | [27] |
| 乙草胺慢性毒性Acetochlor chronic toxicity | | | | | | | | | |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | NOEC | 7 | 0.001 | 0.01 | 95%原药TC | 2 | [28] |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | NOEC | 7 | 0.01 | 2 | [28] |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | NOEC | 7 | 0.1 | 2 | [28] |
| 大型蚤 | *Daphnia magna* | 繁殖Reproduction | LOEL | 6 | 0.1 | 0.1 | 原药TC | 2 | [15] |
| 大型蚤 | *Daphnia magna* | 生长Growth | LOEL | 6 | 0.1 | 2 | [15] |
| 大型蚤 | *Daphnia magna* | 死亡Mortality | NOEL | 6 | 0.1 | 2 | [15] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 4 | 6.7632 | 15.3317 | 原药TC | 2 | [29] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 4 | 34.7561 | 80%原药TC | 2 | [30] |
| 蛋白核小球藻 | *Chlorella pyrenoidosa* | 生长Growth | NOEC | 7 | 1 | 3.1623 | 95%原药TC | 2 | [19] |
| 蛋白核小球藻 | *Chlorella pyrenoidosa* | 生长Growth | NOEC | 7 | 10 | 2 | [19] |
| 稀有鮈鲫 | *Gobiocypris rarus* | 遗传Genetics | NOEC | 21 | 0.0002 | 0.00062 | 99.5%原药TC | 2 | [31] |
| 稀有鮈鲫 | *Gobiocypris rarus* | 遗传Genetics | NOEC | 21 | 0.002 | 2 | [19] |
| 蓝藻水华微囊藻 | *Microcystis flos-aquae* | 生长Growth | NOEC | 9 | 10 | 10 | 90%原药TC | 2 | [32] |
| 克氏原螯虾 | *Procambarus clarkii* | 死亡Mortality | LC50 | 4 | 0.0707 | 0.0707 | 50%乳油EC | 2 | [26] |
| 羊角月牙藻 | *Pseudokirchneriella subcapitat* | 生长Growth | EC50 | 4 | 1.5887 | 1.5887 | 80%原药TC | 2 | [33] |
| 四尾栅藻 | *Scendesmus quadricauda* | 生长Growth | EC50 | 4 | 4.3 | 4.3 | 80%原药TC | 2 | [34] |
| 斜生栅藻 | *scenedesmus obliquu* | 生长Growth | EC50 | 4 | 33.8948 | 33.8948 | 原药TC | 2 | [29] |
| 丙草胺急性毒性Pretilachlor acute toxicity | | | | | | | | | |
| 斑马鱼\* | *Danio rerio* | 生长Growth | EC50 | 4 | 1.36 | 2.204 | 96.8%原药TC | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | LC50 | 4 | 1.74 | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 2.01 | 2 | [21] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 2.02 | 2 | [21] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 2.26 | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 2.57 | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 2.79 | 2 | [21] |
| 大型溞 | *Daphnia magna* | 死亡Mortality | LC50 | 2 | 5.01 | 5.01 | 80%原药TC | 2 | [35] |
| 泥鳅 | *Misgurnus anguillicaudatus* | 死亡Mortality | LC50 | 4 | 0.40197 | 1.372 |  | 2 | [36] |
| 泥鳅 | *Misgurnus anguillicaudatus* | 死亡Mortality | LC50 | 4 | 4.6795 | 2 | [36] |
| 大鳞副泥鳅 | *Paramisgurnus dabryanus* | 死亡Mortality | LC50 | 4 | 0.3265 | 1.293 | 2 | [36] |
| 大鳞副泥鳅 | *Paramisgurnus dabryanus* | 死亡Mortality | LC50 | 4 | 5.1225 | 2 | [36] |
| 克氏原螯虾 | *Procambarus clarkii* | 死亡Mortality | LC50 | 2 | 0.0157 | 0.0157 | 50%乳油EC | 2 | [26] |
| 非洲爪蟾\* | *Xenopus laevis* | 死亡Mortality | LC50 | 4 | 5.35 | 5.350 | 96.2%原药TC | 2 | [27] |
| 热带爪蟾\* | *Xenopus tropicalis* | 死亡Mortality | LC50 | 4 | 4.77 | 4.770 | 2 | [27] |
| 丙草胺慢性毒性Pretilachlor chronic toxicity | | | | | | | | | |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 3 | 0.734 | 20.03 | 96.6%原药TC | 2 | [37] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 3 | 3.304 | 2 | [37] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 4 | 20.03 | 90%原药TC | 2 | [30] |
| 胡鲶 | *Clarias batrachus (Linnaeus)* | 激素 Hormone(s) | LC50 | 30 | 0.29 | 0.4 | 50%乳油EC | 2 | [38] |
| 胡鲶 | *Clarias batrachus (Linnaeus)* | 激素 Hormone(s) | LC50 | 30 | 0.38 | 2 | [38] |
| 胡鲶 | *Clarias batrachus (Linnaeus)* | 激素 Hormone(s) | LC50 | 30 | 0.58 | 2 | [38] |
| 大型溞 | *Daphnia magna* | 生长Growth | EC50 | 21 | 0.55 | 0.08 | 80%原药TC | 2 | [35] |
| 大型溞 | *Daphnia magna* | 繁殖Reproduction | EC50 | 21 | 0.55 | 2 | [35] |
| 大型溞 | *Daphnia magna* | 繁殖Reproduction | MATC | 21 | 0.08 | 2 | [35] |
| 克氏原螯虾 | *Procambarus clarkii* | 死亡Mortality | LC50 | 4 | 0.0119 | 0.0119 | 50%乳油EC | 2 | [30] |
| 月牙藻 | *Selenastrum capricornutum* | 生长Growth | EC50 | 3 | 0.0013 | 0.1109 | 96.6原药TC | 2 | [37] |
| 月牙藻 | *Selenastrum capricornutum* | 生长Growth | EC50 | 3 | 0.0025 | 2 | [37] |
| 月牙藻 | *Selenastrum capricornutum* | 生长Growth | EC50 | 4 | 0.1109 | 90%原药TC | 2 | [30] |
| 丁草胺急性毒性Butachlor acute toxicity | | | | | | | | | |
| 花背蟾蜍 | *Bufo raddei Strauch* | 死亡Mortality | LC50 | 4 | 1.654 | 2.22 | 60%乳油EC | 1 | [39] |
| 花背蟾蜍 | *Bufo raddei Strauch* | 死亡Mortality | LC50 | 4 | 1.928 | 1 | [39] |
| 花背蟾蜍 | *Bufo raddei Strauch* | 死亡Mortality | LC50 | 4 | 3.431 | 1 | [39] |
| 中华大蟾蜍 | *Bufo bufo Gargarizans* | 生长Growth | LC50 | 4 | 0.462 | 0.479 | 60%乳油EC | 2 | [40] |
| 中华大蟾蜍 | *Bufo bufo Gargarizans* | 生长Growth | LC50 | 4 | 0.496 | 2 | [40] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | LC50 | 2 | 3 | 3 | 99%原药TC | 2 | [2] |
| 隆线溞 | *cladoceran Daphnia carinata* | 死亡Mortality | LC50 | 2 | 3.4 | 3.42 | 99.7%原药TC | 2 | [41] |
| 隆线溞 | *cladoceran Daphnia carinata* | 死亡Mortality | LC50 | 2 | 3.45 | 99.2%原药TC | 2 | [5] |
| 鲫鱼 | *crucian* | 死亡Mortality | LC50 | 4 | 0.82 | 0.82 | 60%乳油EC | 2 | [42] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | EC50 | 4 | 0.512 | 0.939799663 | 92.5%原药TC | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 0.32 | 96%原药TC | 2 | [43] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 0.45 | 95%原药TC | 1 | [44] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 0.45 | 95%原药TC | 2 | [45] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | LC50 | 4 | 0.494 | 92.5%原药TC | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 0.919 | 2 | [21] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 0.951 | 50%乳油EC | 1 | [46] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 0.99 | 95%原药TC | 1 | [44] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 1.19 | 92.5%原药TC | 2 | [21] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 1.28 | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 1.73 | 2 | [44] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 1.93 | 95%原药TC | 1 | [44] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 3.37 | 92.5%原药TC | 2 | [21] |
| 泽陆蛙 | *Fejervarya limnocharis* | 死亡Mortality | LC50 | 4 | 0.87 | 0.87 | 60%活性成分a.i. | 2 | [47] |
| 白鲢鱼 | *Hypophthalmicthys molitris* | 死亡Mortality | LC50 | 4 | 0.134 | 0.134 | 60%乳油EC | 2 | [48] |
| 罗氏沼虾 | *Macrobrachium rosenbergii* | 死亡Mortality | LC50 | 2 | 7.71 | 7.71 | 99.2%原药TC | 2 | [49] |
| 贪食沼虾 | *Macrobrachium lar* | 死亡Mortality | LC50 | 2 | 8.18 | 8.18 | 活性成分a.i. | 2 | [50] |
| 泥鳅 | *Misgurnus anguillicaudatus* | 死亡Mortality | LC50 | 4 | 0.39223 | 1.10694 |  | 2 | [36] |
| 泥鳅 | *Misgurnus anguillicaudatus* | 死亡Mortality | LC50 | 4 | 3.124 | 2 | [36] |
| 罗非鱼 | *Oreochromis mossambicus* | 死亡Mortality | LC50 | 4 | 1.25 | 1.25 | 50%乳油EC | 2 | [51] |
| 大鳞副泥鳅 | *Paramisgurnus dabryanus* | 死亡Mortality | LC50 | 4 | 0.16487 | 0.67432 |  | 2 | [36] |
| 大鳞副泥鳅 | *Paramisgurnus dabryanus* | 死亡Mortality | LC50 | 4 | 2.758 | 2 | [36] |
| 克氏原螯虾 | *Procambarus clarkii* | 死亡Mortality | LC50 | 2 | 0.0126 | 0.0126 | 50%乳油EC | 2 | [26] |
| 羊角月牙藻 | *Pseudokirchneriella subcapitat* | 死亡Mortality | LC50 | 1 | 0.14 | 0.14 | 95%原药TC | 2 | [52] |
| 麦穗鱼 | *Pseudorasbora parva* | 死亡Mortality | LC50 | 4 | 0.33 | 0.33 | 60%乳油EC | 2 | [53] |
| 非洲爪蟾\* | *Xenopus laevis* | 死亡Mortality | LC50 | 4 | 2.18 | 2.18 | 92.5%原药TC | 2 | [27] |
| 热带爪蟾\* | *Xenopus tropicalis* | 死亡Mortality | LC50 | 4 | 2.13 | 2.13 |  | 2 | [27] |
| 丁草胺慢性毒性Butachlor chronic toxicity | | | | | | | | | |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 生长Growth | IC50 | 4 | 1.29 | 0.8085 | 99%原药TC | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | IC50 | 4 | 1.19 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | IC50 | 7 | 1.02 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 生长Growth | IC50 | 7 | 1.14 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | MATC | 4 | 0.53 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 生长Growth | MATC | 4 | 0.86 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | MATC | 7 | 0.76 | 2 | [2] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 生长Growth | MATC | 7 | 0.86 | 2 | [2] |
| 蛋白核小球藻 | *Chlorella pyrenoidosa* | 生长Growth | EC50 | 4 | 3.63 | 3.63 | 90%原药TC | 2 | [54] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 4 | 8.6162 | 8.6162 | 93%原药TC | 2 | [30] |
| 斑马鱼\* | *Danio rerio* | 遗传Genetics | LOEC | 10 | 0.0064 | 0.29428 | 96%原药TC | 2 | [43] |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | LOEC | 10 | 0.032 | 2 | [43] |
| 斑马鱼\* | *Danio rerio* | 遗传Genetics | LOEC | 10 | 0.032 | 2 | [43] |
| 斑马鱼\* | *Danio rerio* | 形态Morphology | LOEC | 30 | 0.05 | 1 | [55] |
| 斑马鱼\* | *Danio rerio* | 繁殖Reproduction | LOEC | 30 | 0.05 | 1 | [55] |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | LOEC | 30 | 0.05 | 1 | [55] |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | LOEC | 30 | 0.1 | 1 | [55] |
| 斑马鱼\* | *Danio rerio* | 生理变化Biochemistry | LOEC | 30 | 0.1 | 1 | [55] |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | NOEC | 10 | 0.0064 | 2 | [43] |
| 斑马鱼\* | *Danio rerio* | 遗传Genetics | NOEC | 10 | 0.0064 | 2 | [43] |
| 斑马鱼\* | *Danio rerio* | 遗传Genetics | NOEC | 10 | 0.032 | 2 | [43] |
| 斑马鱼\* | *Danio rerio* | 生理变化Biochemistry | NOEC | 30 | 0.05 | 1 | [55] |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | NOEC | 30 | 0.05 | 1 | [55] |
| 斑马鱼\* | *Danio rerio* | 激素 Hormone(s) | NOEC | 30 | 0.1 | 1 | [55] |
| 斑马鱼\* | *Danio rerio* | 生理变化Biochemistry | NOEC | 30 | 0.1 | 1 | [55] |
| 罗非鱼 | *Oreochromis mossambicus* | 死亡Mortality | LC50 | 7 | 1.092 | 1.092 | 活性成分a.i. | 2 | [50] |
| 尼罗罗非鱼 | *Oreochromis niloticus* | 生理变化Biochemistry | NOEC | 14 | 0.21 | 0.21 |  | 2 | [56] |
| 尼罗罗非鱼 | *Oreochromis niloticus* | 生理变化Biochemistry | NOEC | 21 | 0.21 | 2 | [56] |
| 尼罗罗非鱼 | *Oreochromis niloticus* | 生理变化Biochemistry | NOEC | 28 | 0.21 | 2 | [56] |
| 尼罗罗非鱼 | *Oreochromis niloticus* | 生理变化Biochemistry | NOEC | 42 | 0.21 | 2 | [56] |
| 克氏原螯虾 | *Procambarus clarkii* | 死亡Mortality | LC50 | 4 | 0.0073 | 0.0073 | 50%乳油EC | 2 | [26] |
| 月牙藻 | *Pseudokirchneriella subcapitata* | 生长Growth | EC50 | 4 | 0.2104 | 0.2104 | 90%原药TC | 2 | [33] |
| 四尾栅藻 | *Scendesmus quadricauda* | 生长Growth | EC50 | 4 | 0.2 | 0.2 | 90%原药TC | 2 | [34] |
| 斜生栅藻 | *Scenedesmus obliquus* | 死亡Mortality | EC50 | 4 | 2.31 | 4.03152 | 99.7%原药TC | 2 | [41] |
| 斜生栅藻 | *scenedesmus obliquus* | 生长Growth | EC50 | 4 | 7.036 | 90%原药TC | 2 | [54] |
| 异丙甲草胺急性毒性Metolachlor acute toxicity | | | | | | | | | |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | LC50 | 2 | 15.93 | 15.93 | 36.1%活性成分a.i. | 1 | [3] |
| 莱茵衣藻 | *Chlamydomonas reinhardtii* | 发育Development | EC50 | 2 | 6.9 | 6.9 | 活性成分a.i. | 2 | [57] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | EC50 | 4 | 7.8 | 13.8866 | 92.5%原药TC | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 发育Development | EC50 | 4 | 29.4 | 98.4%原药TC | 2 | [58] |
| 斑马鱼\* | *Danio rerio* | 生长Growth | LC50 | 4 | 3.05 | 92.5%原药TC | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 19 | 1 | [6] |
| 斑马鱼\* | *Danio rerio* | 死亡Mortality | LC50 | 4 | 46.21 | 98.4%原药TC | 2 | [58] |
| 长刺溞 | *Daphnia longispina* | 发育Development | EC50 | 2 | 18.71 | 20.98205 | 活性成分a.i. | 2 | [59] |
| 长刺溞 | *Daphnia longispina* | 发育Development | EC50 | 2 | 23.53 | 2 | [59] |
| 蚤状钩虾 | *Gammarus pulex* | 死亡Mortality | EC50 | 4 | 8.47 | 9.47087 | 98.4%原药TC | 2 | [60] |
| 蚤状钩虾 | *Gammarus pulex* | 死亡Mortality | EC50 | 4 | 10.59 | 2 | [60] |
| 斜生栅藻 | *Scenedesmus obliquus* | 生长Growth | EC50 | 1 | 0.24 | 0.24 | 96%原药TC | 2 | [61] |
| 斜生栅藻 | *Scenedesmus obliquus* | 生长Growth | EC50 | 1 | 0.24 | 2 | [62] |
| 底栖蛤蜊 | *Scrobicularia plana* | 死亡Mortality | LC50 | 4 | 40.702 | 41.10748 | 活性成分a.i. | 2 | [63] |
| 底栖蛤蜊 | *Scrobicularia plana* | 死亡Mortality | LC50 | 4 | 41.517 | 2 | [63] |
| 非洲爪蟾\* | *Xenopus laevis* | 形态Morphology | EC50 | 4 | 15.16 | 13.6 | 98%原药TC | 2 | [64] |
| 非洲爪蟾\* | *Xenopus laevis* | 死亡Mortality | LC50 | 4 | 13.6 | 99%原药TC | 2 | [9] |
| 异丙甲草胺慢性毒性Metolachlor chronic toxicity | | | | | | | | | |
| 金鱼藻 | *Ceratophyllum demersum* | 生长Growth | EC50 | 4 | 0.07 | 0.07 | 94.1%原药TC | 2 | [12] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | LOEC | 7 | 12.5 | 8.84 | 36.1%活性成分a.i. | 1 | [3] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | LOEC | 7 | 25 | 1 | [3] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 繁殖Reproduction | MATC | 7 | 8.84 | 1 | [3] |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | NOEC | 7 | 12.5 | 1 | [3] |
| 衣藻 | *Chlamydomonas* | 生长Growth | EC50 | 4 | 1.138 | 1.138 | 94.1%原药TC | 2 | [12] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 4 | 0.203 | 1.6067 | 94.1%原药TC | 2 | [12] |
| 小球藻 | *Chlorella vulgaris* | 生长Growth | EC50 | 4 | 12.7172 | 原药TC |  | [29] |
| 大型蚤 | *Daphnia magna* | 生长Growth | NOEL | 6 | 0.1 | 0.1 | 原药TC | 2 | [15] |
| 大型蚤 | *Daphnia magna* | 繁殖Reproduction | NOEL | 6 | 0.1 | 2 | [15] |
| 大型蚤 | *Daphnia magna* | 死亡Mortality | NOEL | 6 | 0.1 | 2 | [15] |
| 伊乐藻 | *Elodea* | 生长Growth | EC50 | 4 | 2.355 | 2.355 | 94.1%原药TC | 2 | [12] |
| 浮萍 | *Lemna* | 生长Growth | EC50 | 4 | 0.36 | 0.36 | 94.1%原药TC | 2 | [12] |
| 豹蛙\* | *Lithobates pipiens* | 生长Growth | NOEC | 42 | 0.00022 | 0.00022 | 97%原药TC | 2 | [16] |
| 豹蛙\* | *Lithobates pipiens* | 发育Development | NOEL | 42 | 0.00022 | 2 | [16] |
| 豹蛙\* | *Lithobates pipiens* | 死亡Mortality | NOEL | 42 | 0.00022 | 2 | [16] |
| 豹蛙\* | *Lithobates pipiens* | 生长Growth | NOEL | 42 | 0.00022 | 2 | [16] |
| 茨藻 | *Najas* | 生长Growth | EC50 | 4 | 0.242 | 0.242 | 94.1%原药TC | 2 | [12] |
| 螯虾 | *Orconectes rusticus* | 行为Behavior | LOEL | 4 | 0.025 | 0.05192 | 96.1%原药TC | 1 | [65] |
| 螯虾 | *Orconectes rusticus* | 行为Behavior | LOEL | 4 | 0.08 | 1 | [65] |
| 螯虾 | *Orconectes rusticus* | 行为Behavior | NOEL | 4 | 0.07 | 1 | [65] |
| 青鳉 | *Oryzias latipes* | 遗传Genetics | NOEC | 14 | 0.1 | 0.1 | 98%原药TC | 2 | [66] |
| 四尾栅藻 | *Scendesmus quadricauda* | 生长Growth | EC50 | 4 | 0.6 | 0.6 | 50%湿性粉剂WP | 2 | [34] |
| 斜生栅藻 | *Scenedesmus obliquus* | 生长Growth | EC50 | 4 | 0.13 | 1.5873 | 96%原药TC | 2 | [62] |
| 斜生栅藻 | *scenedesmus obliquu* | 生长Growth | EC50 | 4 | 19.3811 | 原药TC | 2 | [29] |
| 月牙藻 | *Selenastrum* | 生长Growth | EC50 | 4 | 0.084 | 0.084 | 94.1%原药TC | 2 | [12] |
| 敌稗急性毒性Propanil acute toxicity | | | | | | | | | |
| 模糊网纹蚤 | *Ceriodaphnia dubia* | 死亡Mortality | LC50 | 2 | 1.65 | 1.65 | 43.5%活性成分a.i. | 2 | [67] |
| 斑马鱼\* | *Danio rerio* | 形态Morphology | EC50 | 4 | 1.8 | 1.8 | 99.8%原药TC | 2 | [68] |
| 大型蚤 | *Daphnia magna* | 中毒Intoxication | EC50 | 2 | 2.1 | 2.99399 | 活性成分a.i. | 2 | [69] |
| 大型蚤 | *Daphnia magna* | 中毒Intoxication | EC50 | 2 | 3.55 | 商业制剂Commercial formulation | 2 | [70] |
| 大型蚤 | *Daphnia magna* | 中毒Intoxication | EC50 | 2 | 3.6 | 商业制剂Commercial formulation | 2 | [70] |
| 斑点叉尾鮰 | *Ictalurus punctatus* | 死亡Mortality | LC50 | 4 | 0.43 | 1.865 | 88%原药TC | 2 | [71] |
| 斑点叉尾鮰 | *Ictalurus punctatus* | 死亡Mortality | LC50 | 4 | 1.9 | 2 | [70] |
| 斑点叉尾鮰 | *Ictalurus punctatus* | 死亡Mortality | LC50 | 4 | 7.94 | 2 | [70] |
| 青鳉 | *Oryzias latipes* | 发育Development | EC50 | 4 | 9.5 | 9.5 | 99.8%原药TC | 2 | [68] |
| 黑头呆鱼\* | *Pimephales promelas* | 死亡Mortality | LC50 | 4 | 8.6 | 8.6 | 85.9%活性 | 2 | [72] |
| 敌稗慢性毒性Propanil chronic toxicity | | | | | | | | | |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | LOEC | 4 | 0.1 | 0.08367 | 97%原药TC | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理代谢Physiology | LOEC | 4 | 0.07 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | LOEC | 4 | 0.07 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | LOEC | 4 | 0.21 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | LOEC | 4 | 0.55 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | LOEC | 5 | 0.07 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理代谢Physiology | LOEC | 5 | 0.07 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | LOEC | 5 | 0.1 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | LOEC | 5 | 0.21 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | LOEC | 5 | 0.55 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | NOEC | 4 | 0.07 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | NOEC | 4 | 0.1 | 2 | [73] |
| 大型蚤 | *Daphnia magna* | 生理变化Biochemistry | NOEC | 5 | 0.07 | 2 | [73] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | MATC | 54 | 0.000484 | 0.00053 | 85.9%原药TC | 2 | [17] |
| 黑头呆鱼\* | *Pimephales promelas* | 死亡Mortality | MATC | 54 | 0.000582 | 2 | [17] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | LOEC | 54 | 0.000582 | 2 | [17] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | LOEC | 54 | 0.0006 | 85.9%活性成分a.i. | 2 | [72] |
| 黑头呆鱼\* | *Pimephales promelas* | 死亡Mortality | LOEC | 54 | 0.0038 | 2 | [72] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | NOEC | 54 | 0.0004 | 2 | [72] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | NOEC | 54 | 0.000402 | 85.9%原药TC | 2 | [17] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | NOEC | 54 | 0.000582 | 2 | [17] |
| 黑头呆鱼\* | *Pimephales promelas* | 生长Growth | NOEC | 54 | 0.0012 | 85.9%活性成分a.i. | 2 | [72] |
| 黑头呆鱼\* | *Pimephales promelas* | 死亡Mortality | NOEC | 54 | 0.0024 | 2 | [72] |
| 月牙藻 | *Pseudokirchneriella subcapitata* | 生长Growth | EC50 | 4 | 0.012 | 0.01929 | 商业制剂Commercial formulation | 2 | [70] |
| 月牙藻 | *Pseudokirchneriella subcapitata* | 生长Growth | EC50 | 4 | 0.031 | 活性成分a.i. | 2 | [70] |

注：\*为非本土物种；TC为原药；EC为乳油制剂；a.i.为活性成分；EC50为半数效应浓度；LC50为半数致死浓度；IC50为半抑制浓度；MATC为最大可接受毒物浓度；LOEC/L为最低有效应浓度；NOEC/L为最大无效应浓度。

Note: \* means non-native species；TC is the original drug; EC is the emulsifiable concentrate preparation; a.i. is the active ingredient; EC50 is median effective concentration; LC50 is median lethal concentration; IC50 is half maximal inhibitory concentration; MATC is maximum allowable toxicant concentration; LOEC/L is lowest observable effect concentration; NOEC/L is no observable effect concentration.

表S2 拟合模型公式[74]

Table S2 Fit model formula

|  |  |
| --- | --- |
| 模型Model | 拟合公式Fitting formula |
| Normal |  |
| Log-Normal |  |
| Logistic |  |

式中：y-累计概率，%；

x-毒性值， μg·L−1；

μ-毒性值的平均值， μg·L−1；

σ-毒性值的标准差， μg·L−1；

Formula: y-Cumulative probability, %;

x-Toxicity value, μg·L−1;

μ-Average value of toxicity value, μg·L−1;

σ-Standard deviation of toxicity value, μg·L−1;

表S3 ToxRTool数据可靠性评价标准[75]

Table S3 Data reliability evaluation criteria of ToxRTool

|  |  |
| --- | --- |
| 标准Criteria | 体内试验In vivo test |
| 第1组:实验物质的鉴定  Group 1: Test substance identification | 1.受试物是否已被鉴别a Was the test substance identified a |
| 2.是否明确受试物的纯度Is the purity of the substance given |
| 3.受试物的来源是否明确 Is information on the source/origin of the substance given |
| 4.对判断数据必不可少的每个测试项目的理化因素是否都已经明确b  Is all information on the nature and/or physico-chemical properties of the test item given,  which you deem indispensable for judging the data b |
| 第2组:实验体系的特征  Group 2: Test organism characterisation | 5.实验所选物种是否明确 Is the species given |
| 6.性别是否确定 Is the sex of the test organism given |
| 7判定实验动物的血缘、种系c  Is information given on the strain of test animals plus, if considered necessary to judge the study, other specifications c |
| 8.生物的年龄和体重是否给出 Is age or body weight of the test organisms at the start of the study given |
| 9.只针对重复剂量毒理学研究:饲养条件d  For repeated dose toxicity studies only: Is information given on the housing or feeding conditions d |
| 第3组:实验设计的描述  Group 3: Study design description | 10.暴露途径是什么 Is the administration route given |
| 11.剂量或浓度是否给出 Are doses administered or concentrations in application media given |
| 12.暴露频率和持续时间 Are frequency and duration of exposure as well as time-points of observations explained |
| 13.是否有阴性或阳性对照Were negative and positive controls |
| 14.实验动植物数量已知吗Is the number of animals per group given |
| 15.实验过程中暴露溶液的配置、浓度均一性、溶液体积等相关信息是否给出  Whether the configuration, concentration uniformity, solution volume and other relevant information  of the exposure solution are given during the experiment |
| 16.只针对吸入和重复剂量研究 For inhalation studies and repeated dose toxicity studies only |
| 第4组:实验结果的记录  Group 4: Study results documentation | 17.实验终点以及判断终点的方法是否明确  Are the study endpoint(s) and their method(s) of determination clearly described |
| 18.所有试验终点研究结果的描述是否完整和透明  Is the description of the study results for all endpoints investigated transparent and complete |
| 19.数据的统计分析方法是否清晰的表达  Are the statistical methods applied for data analysis given and applied in a transparent manner |
| 第5组:实验设计和结果的可信性  Group 5: Plausibility of study design and results | 20.选择的实验设计对于获得化学品的实验数据是否  Is the study design chosen appropriate for obtaining the substance-specific data aimed at. |
| 21.定量实验结果是否可靠Are the quantitative study results reliable |

注：a受试物鉴别包括化学名称、CAS号、化学结构等，如果是混合物应明确各组成成分。b例如吸入实验的颗粒物大小或刺激性实验的pH值等。c实验动物要考虑动物的级别，如SPF级动物。d温度、湿度、食物、每笼动物数。

Note: a The identification of the test substance includes chemical name, CAS number, chemical structure, etc. If it is a mixture, the components should be clearly defined.b For example, the particle size of inhalation experiments or the pH value of irritation experiments, etc.cThe level of the animal should be considered for experimental animals, such as SPF animals.d Temperature, humidity, food, number of animals per cage.

表S4 ToxRTool分类方法[76]

Table S4 Classification methods in ToxRTool

|  |  |
| --- | --- |
| 分类Classification | 体内试验In vivo test |
| 第1类Category 1 | 18～21分18～21 Score |
| 第2类Category 2 | 13～17分13～17 Score |
| 第3类Category 3 | ＜13分或不满足任意一个斜体字标准  <13 Score or none of the italics criteria met |

**参考文献**（References）：

[1] Howe G E, Gillis R, Mowbray R C. Effect of chemical synergy and larval stage on the toxicity of atrazine and alachlor to amphibian larvae [J]. Environmental Toxicology and Chemistry, 1998, 17(3): 519-525

[2] Oris J T, Winner R W, Moore M V. A four-day survival and reproduction toxicity test for *Ceriodaphnia dubia* [J]. Environmental Toxicology and Chemistry, 1991, 10(2): 217-224

[3] Finger S E, Fairchild J F, Ort M P. Acute and chronic effects of four commercial herbicide formulations on *Ceriodaphnia dubia* [J]. Archives of Environmental Contamination and Toxicology, 1994, 27(1): 103-106

[4] 杨志强, 董波, 吴进才. 普通小球藻对嗪草酮、骠马和甲草胺的敏感性研究[J]. 应用生态学报, 2004, 15(9): 1621-1625

Yang Z Q, Dong B, Wu J C. Sensitivity of *Chlorella vulgaris* to metribuzin, puma and alachlor [J]. Journal of Applied Ecology, 2004, 15(9): 1621-1625 (in Chinese）

[5] He H Z, Chen G K, Yu J, et al. Individual and joint toxicity of three chloroacetanilide herbicides to freshwater cladoceran *Daphnia carinata* [J]. Bulletin of Environmental Contamination and Toxicology, 2013, 90(3): 344-350

[6] 刘迎, 胡燕, 姜蕾, 等. 5种酰胺类除草剂对斑马鱼胚胎发育的毒性效应[J]. 农药, 2014, 53(11): 806-808+811

Liu Y, Hu Y, Jiang L, et al. The toxicity effects of five amide herbicides on embryo development of zebrafish [J]. Agrochemicals, 2014, 53(11): 806-808+811 (in Chinese）

[7] Call D J, Brooke L T, Kent R J, et al. Toxicity, uptake, and elimination of the herbicides alachlor and dinoseb in freshwater fish [J]. Journal of Environmental Quality, 1984, 13(3): 493-498

[8] Lazhar M, Hela T, Moncef B, et al. Toxicity of three selected pesticides (alachlor, atrazine and diuron) to the marine fish (turbot *Tsetta maxima*) [J]. African Journal of Biotechnology, 2012, 11(51): 11321-11328

[9] Osano O, Admiraal W, Otieno D. Developmental disorders in embryos of the frog *Xenopus laevis* induced by chloroacetanilide herbicides and their degradation products [J]. Environmental Toxicology and Chemistry, 2010, 21(2): 375-379

[10] Yi X H, Ding H, Lu Y T, et al. Effects of long-term alachlor exposure on hepatic antioxidant defense and detoxifying enzyme activities in crucian carp (*Carassius auratus*) [J]. Chemosphere, 2007, 68(8): 1576-1581

[11] Yi X H, Liu H H, Lu Y T, et al. Altered serum levels of sex steroids and biotransformation enzyme activities by long-term alachlor exposure in crucian carp (*Carassius auratus*) [J]. Bulletin of Environmental Contamination and Toxicology, 2007, 79(3): 283-287

[12] Fairchild J F, Ruessler D S, Carlson A R. Comparative sensitivity of five species of macrophytes and six species of algae to atrazine, metribuzin, alachlor, and metolachlor [J]. Environmental Toxicology and Chemistry, 2010, 17(9): 1830-1834

[13] Mikula P, Modra H, Nemethova D, et al. Effects of subchronic exposure to lasso MTX (alachlor 42% W/V) on hematological indices and histology of the common carp, *Cyprinus carpio* [J]. Bulletin of Environmental Contamination and Toxicology, 2008, 81(5): 475-479

[14] Chang L W, Toth G P, Gordon D A, et al. Responses of molecular indicators of exposure in mesocosms: common carp (*Cyprinus carpio*) exposed to the herbicides alachlor and atrazine [J]. Environmental Toxicology and Chemistry, 2010, 24(1): 190-197

[15] Kashian D R, Dodson S I. Effects of common-use pesticides on developmental and reproductive processes in daphnia [J]. Toxicology and Industrial Health, 2002, 18(5): 225-235

[16] Hayes T B, Case P, Chui S, et al. Pesticide mixtures, endocrine disruption, and amphibian declines: are we underestimating the impact? [J]. Environmental Health Perspectives, 2006, 114(1): 40-50

[17] Call D J, Geiger D L. Subchronic Toxicities of Industrial and Agricultural Chemicals to Fathead Minnows (*Pimephales promelas*) [M]. Wisconsin: Lake Superior Research Institute, 1992: 271-276

[18] Lee K W, Raisuddin S, Hwang D S, et al. Two-generation toxicity study on the copepod model species *Tigriopus japonicus* [J]. Chemosphere, 2008, 72(9): 1359-1365

[19] 庄航, 薛文, 王柳富, 等. 乙草胺对蛋白核小球藻的毒性效应研究[J]. 生态毒理学报, 2019, 14(5): 188-194

Zhuang H, Xue W, Wang L F, et al. Toxic effects of acetochlor on *Chlorella pyrenoidosa* [J]. Asian Journal of Ecotoxicology, 2019, 14(5): 188-194 (in Chinese）

[20] 杨梅. 乙草胺对斑马鱼的发育和生殖内分泌干扰机制研究[D]*.* 杭州: 浙江大学, 2015: 57-62

Yang M. The development and reproduction endocrine disruption mechanism of acetochlor on zebrafish [D]. Hangzhou: Zhejiang University, 2015: 57-62 (in Chinese)

[21] 程艳红, 葛婧, 胡高洁, 等. 3种酰胺类除草剂对斑马鱼不同生长阶段的急性毒性效应[J]. 生态毒理学报, 2017, 12(6): 171-178

Cheng Y H, Ge J, Hu G J, et al. Acute toxicity effects of three amide herbicides to different life stages of zebrafish (*Danio rerio*) [J]. Asian Journal of Ecotoxicology, 2017, 12(6): 171-178 (in Chinese）

[22] Chang Y M, Mao L G, Zhang L, et al. Combined toxicity of imidacloprid, acetochlor, and tebuconazole to zebrafish (*Danio rerio*): acute toxicity and hepatotoxicity assessment [J]. Environmental Science and Pollution Research, 2020, 27(10): 10286-10295

[23] 刘嗣华. 乙草胺和莠去津对斑马鱼的毒性影响研究[D]*.* 保定: 河北大学, 2007: 10-26

Liu S H. The toxicity effect of acetochlor and atrazine on zebrafish [D]. Baoding: Hebei University, 2007: 10-26 (in Chinese)

[24] Yang M, Hu J J, Li S Y, et al. Thyroid endocrine disruption of acetochlor on zebrafish (*Danio rerio*) larvae [J]. Journal of Applied Toxicology, 2016, 36(6): 844-852

[25] 胡竞进, 曹楚彦, 杨梅, 等. 乙草胺对斑马鱼幼鱼早期发育阶段甲状腺相关基因的影响[J]. 农药学学报, 2015, 17(4): 409-416

Hu J J, Cao C Y, Yang M, et al. Effects of acetochlor on the expression of thyroid related genes in early developmental stages of zebrafish larvae [J]. Chinese Journal of Pesticide Science, 2015, 17(4): 409-416 (in Chinese）

[26] 吴雷明, 韩光明, 王守红, 等. 3种酰胺类稻田除草剂对克氏原螯虾的急性毒性[J]. 生物安全学报, 2019, 28(4): 301-305

Wu L M, Han G M, Wang S H, et al. Acute toxicity of three amide herbicides to *Procambarus clarki* [J]. Journal of Biosafety, 2019, 28(4): 301-305 (in Chinese）

[27] 李贤宾. 三种酰胺类除草剂对热带爪蟾(*Xenopus tropicalis*)早期发育致畸效应及DNA损伤研究[D]*.* 杭州: 浙江大学, 2010: 24-31

Li B X. Teratogenic effects and DNA damage on early development of *Xenopus tropicalis* expose of three amide herbicides [D]. Hangzhou: Zhejiang University, 2010: 24-31 (in Chinese)

[28] Zhang Y Y, Xue W, Long R Z, et al. Acetochlor affects zebrafish ovarian development by producing estrogen effects and inducing oxidative stress [J]. Environmental Science and Pollution Research, 2020, 27(22): 27688-27696

[29] Ma J Y, Liang W. Acute toxicity of 12 herbicides to the green algae *Chlorella pyrenoidosa* and *Scenedesmus obliquus* [J]. Bulletin of Environmental Contamination and Toxicology, 2001, 67(3): 347-351

[30] Ma J Y, Xu L G, Wang S F, et al. Toxicity of 40 herbicides to the green alga *Chlorella vulgaris* [J]. Ecotoxicology and Environmental Safety, 2002, 51(2): 128-132

[31] Li W, Zha J M, Li Z L, et al. Effects of exposure to acetochlor on the expression of thyroid hormone related genes in larval and adult rare minnow (*Gobiocypris rarus*) [J]. Aquatic Toxicology, 2009, 94(2): 87-93

[32] 李俊杰, 李玲, 黄沛玲. 乙草胺胁迫对水华微囊藻光合生理特性的影响[J]. 生态毒理学报, 2020, 15(5): 244-254

Li J J, Li L, Huang P L. Effects of acetochlor stress on photosynthetic physiology of *Microcystisflos-aquae (Wittr).Kirchne*r [J]. Asian Journal of Ecotoxicology, 2020, 15(5): 244-254 (in Chinese）

[33] Ma J Y, Wang S F, Wang P W, et al. Toxicity assessment of 40 herbicides to the green alga *Raphidocelis subcapitata* [J]. Ecotoxicology and Environmental Safety, 2006, 63(3): 456-462

[34] Ma J Y, Lin F, Wang S F, et al. Toxicity of 21 herbicides to the green alga *Scenedesmus quadricauda* [J]. Bulletin of Environmental Contamination and Toxicology, 2003, 71(3): 594-601

[35] Villarroel M J, Sancho E, Ferrando M D, et al. Acute, chronic and sublethal effects of the herbicide propanil on *Daphnia magna* [J]. Chemosphere, 2003, 53(8): 857-864

[36] 亓蒙. 四种水稻除草剂对两种泥鳅的毒性效应[D]*.* 新乡: 河南师范大学, 2015: 2-4

Qi M. The toxic effects of four rice herbicides on two species of loach [D]. Xinxiang: Henan Normal University, 2015: 2-4 (in Chinese)

[37] Kasai F, Hatakeyama S. Herbicide susceptibility in two green algae, *Chlorella vulgaris* and *Selenastrum capricornutum* [J]. Chemosphere, 1993, 27(5): 899-904

[38] Soni R, Verma S K. Impact of herbicide pretilachlor on reproductive physiology of walking catfish, *Clarias batrachus* (linnaeus) [J]. Fish Physiology and Biochemistry, 2020, 46(6): 2065-2072

[39] 边绍康. 除草剂丁草胺对花背蟾蜍胚后早期脑部发育的毒性作用[D]*.* 沈阳: 沈阳师范大学, 2012: 10-28

Bian S K. The toxicity of the herbicide butchlor effects on the brain of Toad Bufo *naddei strauch* in the early period of postembryonic development [D]. Shenyang: Shenyang Normal University, 2012: 10-28 (in Chinese)

1. Bian S K, Chao H, Liang C C, et al. Toxicity of the herbicide butchlor effects on early period of postembryonic development of toad bufo *bufo gargarizans* and bufo *naddei strauch* [J]. International Symposium on IT in Medicine & Education IEEE, 2011, 2: 667-671

[41] He H Z, Yu J, Chen G K, et al. Acute toxicity of butachlor and atrazine to freshwater green alga *Scenedesmus obliquus* and cladoceran *Daphnia carinata* [J]. Ecotoxicology and Environmental Safety, 2012, 80: 91-96

[42] 卢静静. 稻田水中除草剂丁草胺对鲫鱼毒性的研究[D]*.* 长春: 吉林农业大学, 2015: 7-26

Lu J J. Study on toxicological effects of butachlor in *Carasslus* crucian from cropland in the irrigation [D]. Changchun: Jilin Agricultural University, 2015: 7-26 (in Chinese)

[43] Cao C Y, Wang Q W, Jiao F, et al. Impact of co-exposure with butachlor and triadimefon on thyroid endocrine system in larval zebrafish [J]. Experimental and Toxicologic Pathology: Official Journal of the Gesellschaft Fur Toxikologische Pathologie, 2016, 68(8): 463-469

[44] Wang Y H, Lv L, Yu Y J, et al. Single and joint toxic effects of five selected pesticides on the early life stages of zebrafish (*Denio rerio*) [J]. Chemosphere, 2017, 170: 61-67

[45] Wang Y H, Yang G L, Dai D J, et al. Individual and mixture effects of five agricultural pesticides on zebrafish (*Danio rerio*) larvae [J]. Environmental Science and Pollution Research, 2017, 24(5): 4528-4536

[46] 夏勇, 傅剑云, 郑云燕, 等. 丁草胺对斑马鱼及其胚胎发育毒性影响的研究[J]. 浙江预防医学, 2011, 23(1): 11-16

Xia Y, Fu J Y, Zheng Y Y, et al. Study on the toxic of butachlor on zebrafish and its embry development [J]. Zhejiang Journal of Preventive Medicine, 2011, 23(1): 11-16 (in Chinese）

[47] Liu W Y, Wang C Y, Wang T S, et al. Impacts of the herbicide butachlor on the larvae of a paddy field breeding frog (*Fejervarya limnocharis*) in subtropical Taiwan [J]. Ecotoxicology, 2011, 20(2): 337-384

[48] 范立民, 马晓燕, 胡庚东, 等. 除草剂丁草胺对两种鱼的急性毒性研究[J]. 浙江海洋学院学报：自然科学版, 2005, 24(4): 337-339

Fan L M, Ma X Y, Hu G D, et al. Study on acute toxicity of herbicide butachlor to two kinds of fish [J]. Journal of Zhejiang Ocean University: Natural Science Edition, 2005, 24(4): 337-339 (in Chinese）

[49] Wang Y S, Jaw C G, Tang H C, et al. Accumulation and release of herbicides butachlor, thiobencarb, and chlomethoxyfen by fish, clam, and shrimp [J]. Bulletin of Environmental Contamination and Toxicology, 1992, 48(3): 474-480

[50] Bajet C M, Kumar A, Calingacion M N, et al. Toxicological assessment of pesticides used in the Pagsanjan-Lumban catchment to selected non-target aquatic organisms in Laguna Lake, Philippines [J]. Agricultural Water Management, 2012, 106: 42-49

[51] Nwani C D, Ama U I, Okoh F, et al. Acute toxicity of the chloroacetanilide herbicide butachlor and its effects on the behavior of the freshwater fish *Tilapia zillii* [J]. African Journal of Biotechnology, 2013, 12(5): 499-503

[52] 赵锋. 4种除草剂对羊角月牙藻的联合毒性效应[D]*.* 南宁: 广西大学, 2017: 13-21

Zhao F. Combined toxic effects of four herbicides on *Raphidocelis subcapitata* [D]. Nanning: Guangxi University, 2017: 13-21 (in Chinese)

[53] 孟顺龙, 陈家长, 冷春梅. 除草剂阿特拉津与丁草胺对麦穗鱼的联合毒性研究[J]. 环境污染与防治, 2007, 29(4): 254-256

Meng S L, Chen J J, Leng C M. Toxic effects of herbicides atraine and butachlor on topmouth gudgeon (*Pseudorasbora parva*) [J]. Environmental Pollution and Control, 2007, 29(4): 254-256 (in Chinese）

[54] Ma J. Differential sensitivity to 30 herbicides among populations of two green algae *Scenedesmus obliquus* and *Chlorella pyrenoidosa* [J]. Bulletin of Environmental Contamination and Toxicology, 2002, 68(2): 275-281

[55] Chang J H, Liu S Y, Zhou S L, et al. Effects of butachlor on reproduction and hormone levels in adult zebrafish (*Danio rerio*) [J]. Experimental and Toxicologic Pathology, 2013, 65(2): 205-209

[56] Essa M A A, Marzouk M S, Elias N S, et al. Impairment of female *Oreochromis niloticus* fecundity exposed to butachlor herbicide [J]. Journal of Veterinary Medical Research, 2010, 20(1): 38-43

[57] Korkaric M, Behra R, Fischer B B, et al. Multiple stressor effects in *Chlamydomonas reinhardtii*–toward understanding mechanisms of interaction between effects of ultraviolet radiation and chemical pollutants [J]. Aquatic Toxicology, 2015, 162: 18-28

[58] Quintaneiro C, Patricio D, Novais S C, et al. Endocrine and physiological effects of linuron and S-metolachlor in zebrafish developing embryos [J]. Science of the Total Environment, 2017, 586: 390-400

[59] Neves M, Castro B B, Vidal T, et al. Biochemical and populational responses of an aquatic bioindicator species, *Daphnia longispina*, to a commercial formulation of a herbicide (Primextra® Gold TZ) and its active ingredient (S-metolachlor) [J]. Ecological Indicators, 2015, 53: 220-230

[60] Maazouzi C, Coureau C, Piscart C, et al. Individual and joint toxicity of the herbicide S-metolachlor and a metabolite, deethylatrazine on aquatic crustaceans: Difference between ecological groups [J]. Chemosphere, 2016, 165: 118-125

[61] 胡晓娜. 重金属与异丙甲草胺对斜生栅藻的联合毒性及手性选择性差异研究[D]*.* 杭州: 浙江工商大学, 2014: 22-28

Hu X N. Study on combined pollution and enantioselective toxicity between heavy metal and metolachlor on *Scenedesmus obliquus* [D]. Hangzhou: Zhejiang Gongshang University, 2014: 22-28 (in Chinese)

[62] 章小强, 胡晓娜, 陈彩东, 等. 镉与S-异丙甲草胺对斜生栅藻的联合毒性作用[J]. 环境科学, 2015, 36(3): 1069-1074

Zhang X Q, Hu X N, Chen C D, et al. Combined toxicity of cadmium and S-metolachlor to *Scenedesmus obliquus* [J]. Environmental Science, 2015, 36(3): 1069-1074 (in Chinese）

[63] Gutiérrez I, Mesquita A F, Gonçalves F, et al. Biomarkers' responses of the benthic clam *Scrobicularia plana* to the main active ingredients (S-metolachlor and terbuthylazine) of a common herbicide [J]. Ecological Indicators, 2019, 96: 611-619

[64] Gucciardo L S. The Use of Anuran Larvae to Determine Chronic and Acute Toxicological Effects from Exposure to Atrazine and Metolachlor [M]. Iowa: Iowa State University, 1999

[65] Cook M E, Moore P A. The effects of the herbicide metolachlor on agonistic behavior in the crayfish, *Orconectes rusticus* [J]. Archives of Environmental Contamination and Toxicology, 2008, 55(1): 94-102

[66] Jin Y X, Chen R J, Wang L G, et al. Effects of metolachlor on transcription of thyroid system-related genes in juvenile and adult Japanese medaka (*Oryzias latipes*) [J]. General and Comparative Endocrinology, 2011, 170(3): 487-493

[67] Moore M T, Pierce J R, Milam C D, et al. Responses of non-target aquatic organisms to aqueous propanil exposure [J]. Bulletin of Environmental Contamination and Toxicology, 1998, 61(2): 169-174

[68] Schiller V, Zhang X W, Hecker M, et al. Species-specific considerations in using the fish embryo test as an alternative to identify endocrine disruption [J]. Aquatic Toxicology, 2014, 155: 62-72

[69] Pereira J L, Antunes S C, Castro B B, et al. Toxicity evaluation of three pesticides on non-target aquatic and soil organisms: commercial formulation versus active ingredient [J]. Ecotoxicology, 2009, 18(4): 455-463

[70] Pereira J L, Mendes C D, Gongalves F. Short- and long-term responses of *Daphnia spp.* to propanil exposures in distinct food supply scenarios [J]. Ecotoxicology and Environmental Safety, 2007, 68(3): 386-396

[71] Brown K W, Anderson D C, Jones S G, et al. The relative toxicity of four pesticides in tap water and water from flooded rice paddies [J]. International Journal of Environmental Studies, 1979, 14(1): 49-53

[72] Call D J, Brooke L T, Kent R J, et al. Toxicity, bioconcentration, and metabolism of the herbicide propanil (3',4'-dichloropropionanilide) in freshwater fish [J]. Archives of Environmental Contamination and Toxicology, 1983, 12(2): 175-182

[73] Villarroel M J, Sancho E, Andreu-Moliner E, et al. Caloric content of *Daphnia magna* as reflect of propanil stress during a short-term exposure and its relationship to long-term responses [J]. Environmental Toxicology and Pharmacolgy, 2013, 35(3): 465-472

[74] 环境保护部. 淡水水生生物水质基准制定技术指南:HJ 831-2017[S]. 北京:中国环境科学出版社, 2017

Ministry of Ecology and Environmental of the Peopie's Republic of China. Technical Guideline for Deriving Water Quality Criteria for the Protection of Freshwater Aquatic Organisms:HJ 831-2017 [S]. Beijing:China Environmental Press, 2017 (in Chinese)

[75] 李敏, 徐海滨, 何来英. 基于管理毒理学的毒性实验数据的系统评价[J]. 中国食品卫生杂志, 2012, 24(2): 49-53

Li M, Xu H B, He L Y. Systematic review of toxicity laboratory data based on management toxicology [J]. Chinese Journal of Food Hygiene, 2012, 24(2): 49-53 (in Chinese)