Supplementary Materials

Fig. S1 Ecological risk of antibiotics in summer (A) and winter (B) based on the assessment factor method instead of the SSD method.

Table S1 The locations of sampling sites in this study.

Table S2 The aquatic toxicity data and PNEC values for the antibiotics.

Table S3 Concentrations (ng/L) and recoveries of antibiotics and limits of detection (LOD).

Table S4 Resistance risk quotients of antibiotics in the Bohai Bay.

Table S5 Concentrations of antibiotics in coastal waters of the China Seas (ng/L).

Table S6 Ecological risk quotients of antibiotics in the Bohai Bay.



Fig. S1 Ecological risk of antibiotics in summer (A) and winter (B) based on the assessment factor method instead of the SSD method.

Table S1 The locations of sampling sites in this study.

|  |  |  |
| --- | --- | --- |
| Site | Location | Description |
| S1 | 38º54.655′N, 118º31.841′E | Near the Caofeidian Industry Zone |
| S2 | 39º09.628′N, 118º07.737′E | Near the Shahe estuary |
| S3 | 39º12.912′N, 117º57.805′E | Near the Dashentang mariculture area with artificial reefs |
| S4 | 38º58.613′N, 117º52.676′E | Near the Haihe estuary |
| S5 | 38º46.082′N, 117º38.511′E | Near the Duliujianhe estuary |
| S6 | 38º30.198′N, 117º40.201′E | Near the Lijiabao mariculture area by the bottom-sowing mode |
| S7 | 38º24.225′N, 117º55.546′E | Rarely influenced by human activities |
| S8 | 38º13.739′N, 118º06.022′E | Near the Tuhaihe estuary |
| S9 | 38º06.285′N, 118º22.765′E | Near the Xinhu mariculture area with seawater ponds |
| S10 | 38º09.697′N, 118º44.349′E | Rarely influenced by human activities |

Table S2 The aquatic toxicity data and PNEC values for the antibiotics.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Compound | Class | Specie | Endpoint | Values (μg/L) | Reference | PNEC (μg/L) | Comment |
| **Ciprofloxacin** | Algae | *Pseudokirchneriella subcapitata* | NOEC | 500 | (Liu et al. 2011) | 0.001 | BurrliOZ |
|  | Algae | *Platymonas subcordiformis* | NOEC | 5000 | (Wang et al., 2017) |  |  |
|  | Crustaceans | *Daphnia magna* | NOEC | 156 | (Zaleska-Radziwill et al., 2011) |  |  |
|  | Fish | *Lebistes reticulatus* | NOEC | 780 | (Zaleska-Radziwill et al., 2011) |  |  |
|  | Bacteria | *Pseudomonas fluorescens* | NOEC | 0.005 | (Zaleska-Radziwill et al., 2014) |  |  |
|  | Bacteria | *Vibrio fischeri* | NOEC | 0.0015 | (Zaleska-Radziwill et al., 2014) |  |  |
|  | Bacteria | *Pseudomonas aurantiaca* | NOEC | 39.1 | (Zaleska-Radziwill et al., 2014) |  |  |
|  | Plant | *Lemna gibba* | NOEC | 100 | (Brain et al. 2008) |  |  |
|  |  | *Lemna minor* | NOEC | 203 | (Robinson et al., 2005) |  |  |
|  | Rotifer | *Brachionus plicatilis* | NOEC | 10000 | (Wang et al., 2017) |  |  |
|  | Ciliophora | *Tetrahymena thermophila* | NOEC | 195 | (Zaleska-Radziwill et al., 2011) |  |  |
| **Enrofloxacin** | Algae | *Pseudokirchneriella subcapitata* | NOEC | 5.2 | (Harada et al., 2008) | 0.0006 | BurrliOZ |
|  | Algae | *Synechococcus leopolensis* | NOEC | 0.78 | (Andreozzi et al., 2004) |  |  |
|  | Algae | *Selenastrum capricornutum* | NOEC | 100000 | (Halling-Sorensen, 2000) |  |  |
|  | Algae | *Desmodesmus subspicatus* | NOEC | 25 | (Baumann et al., 2015) |  |  |
|  | Crustaceans | *Penaeus monodon* | NOEC | 4,000 | (Tu et al. 2009) |  |  |
|  | Crustaceans | *Daphnia magna* | NOEC | 5,000 | (Park et al. 2008) |  |  |
|  | Crustaceans | *Ceriodaphnia dubia* | NOEC | 30000 | (Constantine and Huggett, 2010) |  |  |
|  | Fish | *Pimephales promelas* | NOEC | 10,000 | (Robinson et al. 2005) |  |  |
|  | Fish | *Lebistes reticulatus* | NOEC | 780 | (Zaleska-Radziwill et al., 2011) |  |  |
|  | Plant | *Lemna gibba* | NOEC | 30 | (Brain et al., 2004) |  |  |
|  | Rotifera | *Brachionus calyciflorus* | NOEC | 12500 | (Ferrari et al., 2004) |  |  |
|  | Bacteria | *Vibrio fischeri* | NOEC | 0.0015 | (Zaleska-Radziwill et al., 2014) |  |  |
| **Erythromycin** | Algae | *Anabaena cylindrica* | NOEC | 3.1 | (Ando et al. 2007) | 0.5 | BurrliOZ |
|  | Algae | *Anabaena flosaquae* | NOEC | 47 | (Ando et al. 2007) |  |  |
|  | Algae | *Microcystis aeruginosa* | NOEC | 10 | (Ando et al. 2007) |  |  |
|  | Algae | *Chlorella vulgaris* | NOEC | 12,500 | (Eguchi et al. 2004) |  |  |
|  | Algae | *Pseudokirchneriella subcapitata* | NOEC | 10.3 | (Eguchi et al. 2004) |  |  |
|  | Crustaceans | *Litopenaeus vannamei* | NOEC | 4,900 | (Williams R R. 1992) |  |  |
|  | Crustaceans | *Daphnia magna* | NOEC | 11,100 | (Ji et al. 2012) |  |  |
|  | Fish | *Oryzias latipes* | NOEC | 1,000,000 | (Ji et al. 2012) |  |  |
|  | Invertebrates | *Moina macrocopa* | NOEC | 50,000 | (Ji et al. 2012) |  |  |
|  | Plant | *Lemna gibba* | NOEC | 300 | (Brain et al. 2004) |  |  |
| **Ofloxacin** | Algae | *Pseudokirchneriella subcapitata* | NOEC | 2500 | (Ferrari et al., 2004) | 0.22 | BurrliOZ |
|  | Algae | *Cyclotella meneghiniana* | NOEC | 31.2 | (Ferrari et al., 2004) |  |  |
|  | Algae | *Synechococcus leopolensis* | NOEC | 5 | (Ferrari et al., 2004) |  |  |
|  | Crustaceans | *Daphnia magna* | NOEC | 10000 | (Robinson et al., 2005) |  |  |
|  | Fish | *Pimephales promelas* | NOEC | 10,000 | (Robinson et al. 2005) |  |  |
|  | Plant | *Lemna gibba* | NOEC | 100 | (Brain et al. 2004) |  |  |
|  | Rotifera | *Brachionus calyciflorus* | NOEC | 12500 | (Ferrari et al., 2004) |  |  |
|  | Bacteria | *Vibrio fischeri* | NOEC | 1.13 | (Backhaus et al., 2000) |  |  |
| **Oxytetracycline** | Algae | *Tetraselmis suecica* | NOEC | 10000 | (Seoane et al., 2014) | 1.76 | BurrliOZ |
|  | Algae | *Pseudokirchneriella subcapitata* | NOEC | 100 | (Eguchi et al. 2004) |  |  |
|  | Algae | *Conticribra weissflogii* | NOEC | 2500 | (Eguchi et al. 2004) |  |  |
|  | Crustaceans | *Litopenaeus vannamei* | NOEC | 3,780,000 | (Bray et al. 2006) |  |  |
|  | Fish | *Anguilla anguilla* | NOEC | 20,000 | (Kreutzmann. 1977) |  |  |
|  | Fish | *Labeo rohita* | NOEC | 80,000 | (Ambili et al. 2013) |  |  |
|  | Fish | *Sparus aurata* | NOEC | 4,000,000 | (Cerezuela et al. 2012) |  |  |
|  | Fish | *Cyprinus carpio* | NOEC | 2,000,000 | (Rijkers et al. 1980) |  |  |
|  | Invertebrates | *Brachionus plicatilis* | NOEC | 5,000 | (Balompapueng et al. 1997) |  |  |
|  | Invertebrates | *Brachionus koreanus* | NOEC | 1 | (Rhee et al., 2012) |  |  |
|  | Molluscs | *Argopecten purpuratus* | NOEC | 4000 | (Miranda et al., 2013) |  |  |
|  | Molluscs | *Pinctada mazatlanica* | NOEC | 10000 | (Aguilar-Macias et al., 2010) |  |  |
| **Sulfamethoxazole** | Algae | *Selenastrum capricornutum* | NOEC | 614 | (Eguchi et al., 2004) | 1.08 | BurrliOZ |
|  | Algae | *L. gibba* | NOEC | 10 | (Brain et al., 2004) |  |  |
|  | Algae | *C. meneghiniana* | NOEC | 1250 | (Ferrari, et al., 2004) |  |  |
|  | Algae | *S. leopolensis* | NOEC | 5.9 | (Ferrari, et al., 2004) |  |  |
|  | Algae | *Pseudokirchneriella subcapitata* | NOEC | 500 | (Liu et al. 2011) |  |  |
|  | Crustacean | *Daphnia magna* | NOEC | 120 | (Lu et al., 2013) |  |  |
|  | Crustacean | *Ceriodaphnia dubia* | NOEC | 250 | (Ferrari et al., 2004) |  |  |
|  | Fish | *Danio rerio* | NOEC | 533 | (Madureira et al. 2011) |  |  |
|  | Fish | *Carassius auratus* | NOEC | 80 | (Li et al. 2012) |  |  |
|  | Plant | *Lemna gibba* | NOEC | 9.4 | (Brain et al. 2008) |  |  |
|  | Invertebrates | *Hydra attenuata* | NOEC | 5,000 | (Quinn et al. 2008) |  |  |
|  | Invertebrates | *Brachionus koreanu* | NOEC | 100 | (Rhee et al., 2012) |  |  |
|  | Invertebrates | *Brachionus calyciflorus* | NOEC | 25000 | (Ferrari et al., 2004) |  |  |
| **Tetracycline** | Algae | *Microcystis aeruginosa* | NOEC | 50 | (Yang et al. 2008) | 1.58 | BurrliOZ |
|  | Algae | *Pseudokirchneriella subcapitata* | NOEC | 500 | (Yang et al. 2013) |  |  |
|  | Crustaceans | *Daphnia magna* | NOEC | 500 | (Kim et al. 2012) |  |  |
|  | Fish | *Oryzias latipes* | NOEC | 20,000 | (Kang. 2006) |  |  |
|  | Plant | *Lemna gibba* | NOEC | 30 | (Brain et al. 2004) |  |  |
|  | Invertebrates | *Brachionus plicatilis* | NOEC | 5,000 | (Balompapueng et al. 1997) |  |  |
|  | Molluscs | *Lamellidens corrianus* | NOEC | 73,820 | (Nandurkar. 2010) |  |  |
| **Trimethoprim** | Algae | *Anabaena cylindrica* | NOEC | 20,000 | (Ando et al. 2007) | 2.4 | BurrliOZ |
|  | Algae | *Pseudokirchneriella subcapitata* | NOEC | 16,000 | (Yang et al. 2008) |  |  |
|  | Crustaceans | *Moina macrocopa* | NOEC | 54,800 | (Park et al. 2008) |  |  |
|  | Crustaceans | *Daphnia magna* | NOEC | 6,000 | (Park et al. 2008) |  |  |
|  | Fish | *Danio rerio* | NOEC | 157 | (Madureira et al. 2012) |  |  |
|  | Fish | *Poecilia reticulata* | NOEC | 25000 | (De Liguoro et al., 2012) |  |  |
|  | Plant | *Lemna gibba* | NOEC | 1,000 | (Brain et al. 2004) |  |  |
|  | Plant | *Lemna minor* | NOEC | 6250 | (De Liguoro et al., 2012) |  |  |
|  | Invertebrates | *Hydra attenuata* | NOEC | 100,000 | (Quinn al. 2008) |  |  |
|  | Invertebrates | *Brachionus koreanus* | NOEC | 10 | (Rhee et al., 2012) |  |  |
| **Amoxicillin** | Algae | *Phaeodactylum tricornutum* | NOEC | 250000 | (De Orte et al., 2013) | 56.6 | BurrliOZ |
|  | Fish | *Danio rerio* | NOEC | 1125000 | (Oliveira et al., 2013) |  |  |
|  | Plant | *Lemna gibba* | NOEC | 1000 | (Brain et al., 2004) |  |  |
|  | Invertebrates | *Hydra vulgaris* | NOEC | 10000 | (Pascoe et al., 2003) |  |  |
| **Ampicillin** | Algae | *Microcystis aeruginosa* | NOEC | 10 | (Qian et al., 2012) | 0.1 | NOEC(Algae), AF=100 |
|  | Algae | *Chlorella vulgaris* | NOEC | >10000000 | (Eguchi et al., 2004) |  |  |
|  | Invertebrates | *Arbacia lixula* | NOEC | 10000 | (Carballeira et al., 2012) |  |  |
|  | Invertebrates | *Paracentrotus lividus* | NOEC | 100000 | (Carballeira et al., 2012) |  |  |
| **Doxycycline** | Plant | *Lemna gibba* | NOEC | 100 | (Brain et al., 2004) | 0.1 | NOEC(Plant), AF=1000 |
| **Penicillin** | Algae | *Pseudokirchneriella subcapitata* | NOEC | 100000 | (Halling-Sorensen, 2000) | 100 | NOEC(Algae), AF=1000 |
|  | Algae | *Selenastrum capricornutum* | NOEC | 1000000 | (Halling-Sorensen, 2000) |  |  |
| **Roxithromycin** | Algae | *P. subcapitata* | NOEC | 10 | (Yang et al., 2008) | 0.02 | NOEC(Algae), AF=500 |
|  | Plant | *Lemna gibba* | NOEC | 1000 | (Brain et al., 2004) |  |  |

Table S3 Concentrations (ng/L) and recoveries of antibiotics and limits of detection (LOD).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Mean | Min | Max | Det. freq. (%) | Recovery (%) | LOD (ng/L) |
| AMX | Summer | 2.2 | ND | 5.5 | 60 | 93 | 0.06 |
| Winter | 4.1 | ND | 11.6 | 80 | 97 | 0.10 |
| AMP | Summer | - | ND | ND | 0 | 86 | 0.24 |
| Winter | 0.3 | ND | 0.4 | 90 | 98 | 0.04 |
| PNC | Summer | 2.2 | ND | 5.1 | 50 | 94 | 0.52 |
| Winter | 1.4 | ND | 2.3 | 80 | 96 | 0.36 |
| CIP | Summer | - | ND | ND | 0 | 89 | 0.18 |
| Winter | 2.3 | 1.3 | 2.8 | 100 | 99 | 0.21 |
| ENR | Summer | - | ND | ND | 0 | 91 | 0.31 |
| Winter | 6.6 | ND | 10.4 | 70 | 96 | 0.19 |
| OFL | Summer | 5.7 | 4.3 | 15.3 | 100 | 101 | 0.23 |
| Winter | 0.7 | ND | 0.5 | 80 | 94 | 0.04 |
| SMX | Summer | 6.7 | 1.9 | 17.5 | 100 | 91 | 0.26 |
| Winter | 6.2 | 1.7 | 18.2 | 100 | 98 | 0.48 |
| TMP | Summer | - | ND | ND | 0 | 93 | 0.64 |
| Winter | 2.2 | 0.5 | 5 | 100 | 97 | 0.16 |
| DOX | Summer | 3.3 | 2.3 | 3.7 | 100 | 94 | 0.07 |
| Winter | 0.6 | 0.1 | 1.3 | 100 | 96 | 0.03 |
| OTC | Summer | 20.9 | ND | 200.9 | 30 | 86 | 0.11 |
| Winter | 129.1 | 25.5 | 252.2 | 100 | 94 | 0.37 |
| TC | Summer | 6.2 | 3.0 | 11.8 | 100 | 92 | 0.36 |
| Winter | 4.8 | 1.3 | 17.2 | 100 | 93 | 0.20 |
| ERY | Summer | - | ND | ND | 0 | 82 | 0.39 |
| Winter | 0.3 | ND | 0.4 | 90 | 92 | 0.09 |
| ROX | Summer | - | ND | ND | 0 | 82 | 0.77 |
| Winter | - | ND | ND | 0 | 80 | 0.52 |

ND, Not Detected.

Table S4 Resistance risk quotients of antibiotics in the Bohai Bay.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Antibiotics | Season | Mean | Min | Max |
| AMX | Summer | 8.7E-03 | 0.0E+00 | 2.2E-02 |
| Winter | 1.3E-02 | 0.0E+00 | 4.6E-02 |
| AMP | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 9.3E-04 | 0.0E+00 | 1.6E-03 |
| PNC | Summer | 8.8E-03 | 0.0E+00 | 2.0E-02 |
| Winter | 4.6E-03 | 0.0E+00 | 9.0E-03 |
| CIP | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 3.6E-02 | 2.1E-02 | 4.4E-02 |
| ENR | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 7.2E-02 | 0.0E+00 | 1.6E-01 |
| OFL | Summer | 1.1E-02 | 8.7E-03 | 3.1E-02 |
| Winter | 1.1E-03 | 0.0E+00 | 6.8E-03 |
| SMX | Summer | 4.2E-04 | 1.2E-04 | 1.1E-03 |
| Winter | 3.9E-04 | 1.1E-04 | 1.1E-03 |
| TMP | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 4.3E-03 | 1.1E-03 | 1.0E-02 |
| DOX | Summer | 1.6E-03 | 1.2E-03 | 1.8E-03 |
| Winter | 3.2E-04 | 6.7E-05 | 6.7E-04 |
| OTC | Summer | 4.2E-02 | 0.0E+00 | 4.0E-01 |
| Winter | 2.6E-01 | 5.1E-02 | 5.3E-01 |
| TC | Summer | 6.2E-03 | 3.0E-03 | 1.2E-02 |
| Winter | 4.8E-03 | 1.3E-03 | 1.7E-02 |
| ERY | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 2.9E-04 | 0.0E+00 | 4.0E-04 |
| ROX | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 0.0E+00 | 0.0E+00 | 0.0E+00 |

Table S5 Concentrations of antibiotics in coastal waters of the China Seas (ng/L).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coastal area in China | AMP | | AMX | | PNC | | CIP | | ENR | | OFL | | SMX | | References |
| min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) | min/  mean/  max n | Frq  (%) | min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) |
| (Jia et al., 2011) | -b | - | - | - | - | - | - | - | - | - | - | - | 4.3/  30.6/  76.9/ | 100.0 | (Jia et al., 2011) |
| This study | ND | 60.0 | ND/  3.6/  5.5 | 0 | ND/  4.4/  5.1 | 50.0 | ND/  ND/  ND | 0 | ND/  ND/  ND | 0 | 4.3/  5.7/  15.3 | 100.0 | 1.9/  6.7/  17.5 | 100.0 | This study |
| (Zhang et al., 2012) | - | - | - | - | - | - | ND/  44.2/  66.1 | 71.4 | ND/  ND/  ND/ | 0 | ND/  18.5/  33.9 | 42.9 | 25.0/  112.6/  329.5 | 100.0 | (Zhang et al., 2012) |
| (Zhang et al., 2013) | - | - | - | - | - | -- | - | - | -- | - | - | - | 0.2/  0.3/  0.6 | 100.0 | (Zhang et al., 2013) |
| (Zhang et al., 2013) | - | - | - | - | - | - | - | - | - | - | - | - | 0.2/  0.8/  1.4 | 80.0 | (Zhang et al., 2013) |
| (Du et al., 2017) | ND/  7.7/  48.1 | 56.7 | 1.4/  7.2/  95.8 | 100.0 | ND/  0.4/  11.8 | 3.3 | ND/  7.2/  121.2 | 33.3 | ND/  25.4/  497.6 | 26.7 | - | - | - | - | (Du et al., 2017) |
| (Yan et al., 2013) | - | - | - | - | - | - | ND | 0 | ND | 0 | ND | 0 | 1.5/  17.6 /  28.5 | 100.0 | (Yan et al., 2013) |
| (Minh et al., 2009) | - | - | 0.6/  16.0/  76.0 | 90.0 | - | - | 6.1/  74.0/  504.0 | 100.0 | - | - | 8.1/  156.0/  1140.0 | 100.0 | 0.6/  13.0/  47.0 | 100.0 | (Minh et al., 2009) |
| (Chen et al., 2015) | - | - | - | - | - | - | -/  5.3/  187.0 | 13.2 | -/  2.0/  56.7 | 23.7 | -/  0.8/  13.7 | 55.3 | -/  1.3/  6.2 | 76.3 | (Chen et al., 2015) |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TMP | | DOX | | OTC | | TC | | ERY | | ROX | | References |
| Coastal area in China | min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) | min/  mean/  max | Frq  (%) |
| Liaodong Bay | 3.5/  7.9/  10.2 | 100.0 | - | - | - | - | - | - | - | - | - |  | (Jia et al., 2011) |
| Bohai Bay (In Summer) | ND/  ND/  ND/ | 0 | 2.6/  3.3/  3.7 | 100.0 | ND/  69.8/  200.9 | 30.0 | 3/  6.2/  11.8 | 100.0 | ND | 0 | ND | 0 | This study |
| Laizhou Bay | 9.5/  100.0/  329.5 | 100.0 | - | 0 | - | 0 | - | 0 | 1.8/  5.0/  8.5 | 100.0 | <LOQ  1.31/  1.5 | 37.5 | (Zhang et al., 2012) |
| North Yellow Sea | 0.4/  0.5/  1.1 | 100.0 | - | - | - | - | - | - | 0.3  0.3/  0.5 | 100.0 | <LOQ | 0 | (Zhang et al., 2013) |
| South Yellow Sea | <LOQ  0.3/  0.6 | 100.0 | - | - | - | - | - | - | 0.2/  0.3/  0.4 | 100.0 | <LOQ | 0 | (Zhang et al., 2013) |
| Yellow Sea  (Yancheng Area) | - | - | - | - | - | - | - | - | ND/  0.5/  1.7 | 70.0 | ND/  2.7/  77.1 | 13.3 | (Du et al., 2017) |
| East China and Yangtze Estuary (In July) | - | - | ND | 0 | ND | 0 | ND | 0 | <LOQ  0.8/  4.5 | 100.0 | 0.2/  0.4/  8.2 | 100.0 | (Yan et al., 2013) |
| Victoria Habour | 2.6/  52.0/  216.0 | 50.0 | - | - | 16.0/  30.0/  44.0 | 10.0 | 13.0/  118.0/  313.0 | 30.0 | 4.7/  213.0/  1730.0 | 100.0 | 5.5/  19.0/  47 | 35.0 | (Minh et al., 2009) |
| Hailing Bay | -/  4.24/  36.9 | 100.0 | - | - | -/  417.8/15163.0 | 23.7 | -/  78.5/  2305.0 | 15.8 | -/  18.5/  183.0 | 94.7 | - | - | (Chen et al., 2015) |

Frq: Frequency

ND: Not Detected

“ - “: Not Analyzed

Table S6 Ecological risk quotients of antibiotics in the Bohai Bay.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Antibiotics | Season | Mean | Min | Max |
| AMX | Summer | 3.8E-05 | 0.0E+00 | 9.7E-05 |
| Winter | 5.7E-05 | 0.0E+00 | 2.0E-04 |
| AMP | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 2.3E-03 | 0.0E+00 | 4.0E-03 |
| PNC | Summer | 2.2E-05 | 0.0E+00 | 5.1E-05 |
| Winter | 1.2E-05 | 0.0E+00 | 2.3E-05 |
| CIP | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 2.3E+00 | 1.3E+00 | 2.8E+00 |
| ENR | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 7.7E+00 | 0.0E+00 | 1.7E+01 |
| OFL | Summer | 2.6E-02 | 2.0E-02 | 6.9E-02 |
| Winter | 2.5E-03 | 0.0E+00 | 1.5E-02 |
| SMX | Summer | 6.2E-03 | 1.7E-03 | 1.6E-02 |
| Winter | 5.7E-03 | 1.6E-03 | 1.7E-02 |
| TMP | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 9.0E-04 | 2.2E-04 | 2.1E-03 |
| DOX | Summer | 3.3E-02 | 2.3E-02 | 3.7E-02 |
| Winter | 6.5E-03 | 1.3E-03 | 1.3E-02 |
| OTC | Summer | 1.2E-02 | 0.0E+00 | 1.1E-01 |
| Winter | 7.3E-02 | 1.5E-02 | 1.5E-01 |
| TC | Summer | 3.9E-03 | 1.9E-03 | 7.5E-03 |
| Winter | 3.0E-03 | 8.0E-04 | 1.1E-02 |
| ERY | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 5.9E-04 | 0.0E+00 | 8.0E-04 |
| ROX | Summer | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| Winter | 0.0E+00 | 0.0E+00 | 0.0E+00 |

Reference

Aguilar-Macias O. L., Ojeda-Ramirez J. J., Campa-Cordova A. I., Saucedo P. E., 2010. Evaluation of Natural and Commercial Probiotics for Improving Growth and Survival of the Pearl Oyster, Pinctada Mazatlanica, During Late Hatchery and Early Field Culturing. Journal of the World Aquaculture Society. 41, 447-454.

Ambili TR, Saravanan M, Ramesh M, Abhijith DB, Poopal RK., 2013. Toxicological Effects of the Antibiotic Oxytetracycline to an Indian Major Carp Labeo rohita. Arch Environ Contam Toxicol 64:494-503.

Ando T, Nagase H, Eguchi K, Hirooka T, Nakamura T, Miyamoto K, Hirata K., 2007 A novel method using cyanobacteria for ecotoxicity test of veterinary antimicrobial agents. Environ Toxicol Chem 26:601-606.

Andreozzi R., Caprio V., Ciniglia C., De Champdore M., Lo Giudice R., Marotta R., Zuccato E., 2004. Antibiotics in the Environment: Occurrence in Italian Stps, Fate, and Preliminary Assessment on Algal Toxicity of Amoxicillin. Environmental Science & Technology. 38, 6832-6838.

Backhaus T., Scholze M., Grimme L. H., 2000. The Single Substance and Mixture Toxicity of Quinolones to the Bioluminescent Bacterium Vibrio Fischeri. Aquatic Toxicology. 49, 49-61.

Balompapueng MD, Munuswamy N, Hagiwara A, Hirayama K., 1997. Effect of disinfectants on the hatching of marine rotifer resting eggs Brachionus plicatilis Muller. Aquac Res 28:559-565.

Baumann M., Weiss K., Maletzki D., Schuessler W., Schudoma D., Kopf W., Kuehnen U., 2015. Aquatic Toxicity of the Macrolide Antibiotic Clarithromycin and Its Metabolites. Chemosphere. 120, 192-198.

Brain RA, Johnson DJ, Richards SM, Sanderson H, Sibley PK, Solomon KR., 2004. Effects of 25 pharmaceutical compounds to Lemna gibba using a seven-day static-renewal test. Environ Toxicol Chem 23:371-382.

Brain RA, Ramirez AJ, Fulton BA, Chambliss CK, Brooks BW., 2008. Herbicidal Effects of Sulfamethoxazole in Lemna gibba: Using p-Aminobenzoic Acid As a Biomarker of Effect. Environ Sci Technol 42:8965-8970.

Bray WA, Williams RR, Lightner DV, Lawrence AL., 2006. Growth, survival and histological responses of the marine shrimp, Litopenaeus vannamei, to three dosage levels of oxytetracycline. Aquaculture 258:97-108.

Carballeira C., De Orte M. R., Viana I. G., DelValls T. A., Carballeira A., 2012. Assessing the Toxicity of Chemical Compounds Associated with Land-Based Marine Fish Farms: The Sea Urchin Embryo Bioassay with Paracentrotus Lividus and Arbacia Lixula. Archives of Environmental Contamination and Toxicology. 63, 249-261.

Cerezuela R, Guardiola FA, Meseguer J, Esteban MA., 2012. Increases in immune parameters by inulin and Bacillus subtilis dietary administration to gilthead seabream (Sparus aurata L.) did not correlate with disease resistance to Photobacterium damselae. Fish & Shellfish Immunol 32:1032-1040.

Chen H., Liu S., Xu X. R., Zhou G. J., Liu S. S., Yue W. Z., Sun K. F., Ying G. G., 2015. Antibiotics in the Coastal Environment of the Hailing Bay Region, South China Sea: Spatial Distribution, Source Analysis and Ecological Risks. Mar Pollut Bull. 95, 365-373.

Constantine L. A., Huggett D. B., 2010. A Comparison of the Chronic Effects of Human Pharmaceuticals on Two Cladocerans, Daphnia Magna and Ceriodaphnia Dubia. Chemosphere. 80, 1069-1074.

De Liguoro M., Di Leva V., Dalla Bona M., Merlanti R., Caporale G., Radaelli G., 2012. Sublethal Effects of Trimethoprim on Four Freshwater Organisms. Ecotoxicology and Environmental Safety. 82, 114-121.

De Orte M. R., Carballeira C., Viana I. G., Carballeira A., 2013. Assessing the Toxicity of Chemical Compounds Associated with Marine Land-Based Fish Farms: The Use of Mini-Scale Microalgal Toxicity Tests. Chemistry and Ecology. 29, 554-563.

Du J., Zhao H., Liu S., Xie H., Wang Y., Chen J., 2017. Antibiotics in the Coastal Water of the South Yellow Sea in China: Occurrence, Distribution and Ecological Risks. Sci Total Environ. 595, 521-527.

Eguchi K, Nagase H, Ozawa M, Endoh YS, Goto K, Hirata K, Miyamoto K, Yoshimura H., 2004. Evaluation of antimicrobial agents for veterinary use in the ecotoxicity test using microalgae. Chemosphere 57:1733-1738.

Ferrari B., Mons R., Vollat B., Fraysse B., Paxeus N., Lo Giudice R., Pollio A., Garric J., 2004. Environmental Risk Assessment of Six Human Pharmaceuticals: Are the Current Environmental Risk Assessment Procedures Sufficient for the Protection of the Aquatic Environment? Environmental Toxicology and Chemistry. 23, 1344-1354.

Halling-Sorensen B., 2000. Algal Toxicity of Antibacterial Agents Used in Intensive Farming. Chemosphere. 40, 731-739.

Harada A., Komori K., Nakada N., Kitamura K., Suzuki Y., 2008. Biological Effects of Ppcps on Aquatic Lives and Evaluation of River Waters Affected by Different Wastewater Treatment Levels. Water Science and Technology. 58, 1541-1546.

Jia A., Hu J., Wu X., Peng H., Wu S., Dong Z., 2011. Occurrence and Source Apportionment of Sulfonamides and Their Metabolites in Liaodong Bay and the Adjacent Liao River Basin, North China. Environmental Toxicology and Chemistry. 30, 1252-1260.

Ji K, Kim S, Han S, Seo J, Lee S, Park Y, Choi K, Kho YL, Kim PG, Park J, Choi K., 2012. Risk assessment of chlortetracycline, oxytetracycline, sulfamethazine, sulfathiazole, and erythromycin in aquatic environment: are the current environmental concentrations safe? Ecotoxicology 21:2031-2050.

Kang HJ, K. Choi, M.Y. Kim,P.G. Kim., 2006. Endocrine Disruption Induced by Some Sulfa Drugs and Tetracyclines on Oryzias latipes. Korean J Environ Health Sci 32:227-234.

Kreutzmann HL., 1977. The effects of chloramphenicol and oxytetracycline on haematopoiesis in the European eel (Anguilla anguilla). Aquaculture 10:323-334

Li ZH, Lu GH, Yang XF, Wang C., 2012. Single and combined effects of selected pharmaceuticals at sublethal concentrations on multiple biomarkers in Carassius auratus. Ecotoxicology 21:353-361.

Liu BY, Nie XP, Liu WQ, Snoeijs P, Guan C, Tsui MTK., 2011. Toxic effects of erythromycin, ciprofloxacin and sulfamethoxazole on photosynthetic apparatus in Selenastrum capricornutum. Ecotoxicol Environ Safety 74:1027-1035.

Luo Y., Mao D. Q., Rysz M., Zhou D. X., Zhang H. J., Xu L., Alvarez P. J. J., 2010. Trends in Antibiotic Resistance Genes Occurrence in the Haihe River, China. Environmental Science & Technology. 44, 7220-7225.

Lu G., Li Z., Liu J., 2013. Effects of Selected Pharmaceuticals on Growth, Reproduction and Feeding of Daphnia Magna. Fresenius Environmental Bulletin. 22, 2583-2589.

Madureira TV, Rocha MJ, Cruzeiro C, Galante MH, Monteiro RAF, Rocha E., 2011. The toxicity potential of pharmaceuticals found in the Douro River estuary (Portugal): Assessing impacts on gonadal maturation with a histopathological and stereological study of zebrafish ovary and testis after sub-acute exposures. Aquat Toxicol 105:292-299.

Minh T. B., Leung H. W., Loi I. H., Chan W. H., So M. K., Mao J. Q., Choi D., Lam J. C., Zheng G., Martin M., Lee J. H., Lam P. K., Richardson B. J., 2009. Antibiotics in the Hong Kong Metropolitan Area: Ubiquitous Distribution and Fate in Victoria Harbour. Mar Pollut Bull. 58, 1052-1062.

Miranda C. D., Rojas R., Abarca A., Hurtado L., 2013. Effect of Florfenicol and Oxytetracycline Treatments on the Intensive Larval Culture of the Chilean Scallop Argopecten Purpuratus (Lamarck, 1819). Aquaculture Research. 45, 16-30.

Nandurkar HP, S.P. Zambare., 2010. Tetracycline and chloramphenicol activity on the rate of oxygen consumption in (the experimental animal) freshwater bivalve Lamellidens corrianus (LEA). Natl J Life Sci 7:45-48.

Oliveira R., McDonough S., Ladewig J. C. L., Soares A. M. V. M., Nogueira A. J. A., Domingues I., 2013. Effects of Oxytetracycline and Amoxicillin on Development and Biomarkers Activities of Zebrafish (Danio Rerio). Environmental Toxicology and Pharmacology. 36, 903-912.

Park S, Choi K., 2008. Hazard assessment of commonly used agricultural antibiotics on aquatic ecosystems. Ecotoxicology 17:526-538.

Pascoe D., Karntanut W., Muller C. T., 2003. Do Pharmaceuticals Affect Freshwater Invertebrates? A Study with the Cnidarian Hydra Vulgaris. Chemosphere. 51, 521-528.

Qian H., Pan X., Chen J., Zhou D., Chen Z., Zhang L., Fu Z., 2012. Analyses of Gene Expression and Physiological Changes in Microcystis Aeruginosa Reveal the Phytotoxicities of Three Environmental Pollutants. Ecotoxicology. 21, 847-859.

Quinn B, Gagne F, Blaise C., 2008. An investigation into the acute and chronic toxicity of eleven pharmaceuticals (and their solvents) found in wastewater effluent on the cnidarian, Hydra attenuata. Sci Total Environ 389:306-314.

Rhee J.-S., Jeong C.-B., Kim B.-M., Lee J.-S., 2012. P-Glycoprotein (P-Gp) in the Monogonont Rotifer, Brachionus Koreanus: Molecular Characterization and Expression in Response to Pharmaceuticals. Aquatic Toxicology. 114, 104-118.

Rijkers GT, Teunissen AG, Vanoosterom R, Vanmuiswinkel WB., 1980. Immune-system of cyprinid fish - immunosuppressive effect of the antibiotic oxytetracycline in carp (cyprinus-carpio l). Aquaculture 19:177-189.

Robinson AA, Belden JB, Lydy MJ., 2005. Toxicity of fluoroquinolone antibiotics to aquatic organisms. Environ Toxicol Chem 24:423-430.

Seoane M., Rioboo C., Herrero C., Cid A., 2014. Toxicity Induced by Three Antibiotics Commonly Used in Aquaculture on the Marine Microalga Tetraselmis Suecica (Kylin) Butch. Marine Environmental Research. 101, 1-7.

SEPA (State Environmental Protection Administration), 2002. Methods of monitoring and analysis for water and wastewater. China Environmental Science Press. Beijing. China.

Tu HT, Silvestre F, Scippo ML, Thome JP, Phuong NT, Kestemont P., 2009. Acetylcholinesterase activity as a biomarker of exposure to antibiotics and pesticides in the black tiger shrimp (Penaeus monodon). Ecotoxicol Environ Safety 72:1463-1470

Wang C., Wang Z., Zhang Y., Su R., 2017. Interspecies Interactions Reverse the Hazard of Antibiotics Exposure: A Plankton Community Study on Responses to Ciprofloxacin Hydrochloride. Scientific Reports. 7, 2373-2373.

Williams R R BTA, Lightner D V., 1992. Shrimp Antimicrobial Testing:Toxicity Testing and Safety Determination for Twelve Antimicrobials with Penaeid Shrimp Larvae. J Aquat Anim Health 4:262-270.

Yang LH, Ying GG, Su HC, Stauber JL, Adams MS, Binet MT., 2008. Growth-inhibiting effects of 12 antibacterial agents and their mixtures on the freshwater microalga Pseudokirchneriella subcapitata. Environ Toxicol Chem 27:1201-1208

Yan C., Yang Y., Zhou J., Liu M., Nie M., Shi H., Gu L., 2013. Antibiotics in the Surface Water of the Yangtze Estuary: Occurrence, Distribution and Risk Assessment. Environ Pollut. 175, 22-29.

Zaleska-Radziwill M., Affek K., Rybak J., 2014. Ecotoxicity of Chosen Pharmaceuticals in Relation to Micro-Organisms-Risk Assessment. Desalination and Water Treatment. 52, 3908-3917.

Zaleska-Radziwill M., Lebkowska M., Affek K., Zarzeczna A., 2011. Environmental Risk Assessment of Selected Pharmaceuticals Present in Surface Waters in Relation to Animals. Archives of Environmental Protection. 37, 31-42.

Zhang R., Zhang G., Zheng Q., Tang J., Chen Y., Xu W., Zou Y., Chen X., 2012. Occurrence and Risks of Antibiotics in the Laizhou Bay, China: Impacts of River Discharge. Ecotoxicol Environ Saf. 80, 208-215.

Zhang R. J., Tang J. H., Li J., Zheng Q., Liu D., Chen Y. J., Zou Y. D., Chen X. X., Luo C. L., Zhang G., 2013. Antibiotics in the Offshore Waters of the Bohai Sea and the Yellow Sea in China: Occurrence, Distribution and Ecological Risks. Environmental Pollution. 174, 71-77.