Scholar Publishing Group
Academic Journal of Environmental Biology
https://doi.org/10.38007/AJEB.2022.030307
ISSN 2789-8407 Vol. 3, Issue 3: 52-59

Acute Toxicity and Safety Evaluation of Pesticides to Environmental Organisms

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Keywords: Agricultural Chemicals, Environmental Biology, Acute Toxicity, Safety Evaluation

Abstract: Pesticides are an important means to ensure agricultural harvest. Their long-term repeated use leads to a large number of residues in the farmland environment, while pesticides left in soil and water are easy to migrate to non target crops, further affecting plant physiological metabolism and rhizosphere environment. This paper mainly studied the acute toxicity of pesticides to environmental organisms and the safety evaluation of fish. This paper first analyzes the impact of environmental pollutants on plants, explores several commonly used pesticide detection technologies, and preliminarily evaluates the ecological risk caused by pesticide residues in river surface water and farmland soil according to the risk assessment method recommended by USEPA. According to the evaluation results, the pesticide residues in the rivers and soils of cities a and B selected in this paper meet the safety standards.

1. Introduction

Pesticides are a kind of chemical substances, which can be divided into pesticides, herbicides, fungicides, etc. according to the control objects, in order to protect crops from fungal diseases, pests and weeds, and then improve the output of agricultural products [1-2]. With the accelerated development of the agricultural process, the application of pesticides in agriculture has increased sharply. However, due to the incorrect and extensive use of pesticides, it has a negative impact on the quality of human life and the environment, and the environmental pollution of pesticides has aroused great concern. There are many ways for pesticides to enter the environment, such as pesticides acting directly on the soil; Residual pesticides absorbed by crops enter rivers with surface runoff; The sprayed pesticide air settles into the water body; Pesticides in soil enter groundwater through infiltration, dissolution and other ways. Pesticides entering the environment have certain toxic effects on aquatic organisms. Studies have shown that organophosphorus pesticides can inhibit the production of acetylcholinesterase in organisms, cause acute poisoning of fish, and also affect tissue metabolism and pathological changes. Organochlorine pesticides can inhibit immune and reproductive systems, regulate lipid and metabolic disorders, and have teratogenic and endocrine disrupting effects [3]. Pyrethroid pesticides can accumulate in fish and cause physiological lesions. Some pesticides can also inhibit the growth of plants and microorganisms; Herbicides can greatly inhibit the growth rate, chlorophyll content and photosynthetic efficiency of freshwater plants. In addition, some herbicides have been found to have teratogenic, mutagenic and endocrine disrupting effects on aquatic organisms [4]. Pesticides can accumulate in organisms through the food chain, posing a threat to human health and the stability of aquatic ecosystems.

Due to the low concentration of target pesticide compounds and the complex and diverse matrix of environmental water, sample pretreatment is essential. The traditional pretreatment methods for pesticides in environmental water include solid phase extraction (SPE), solid phase microextraction (SPME), and analytical imprinted polymer (MTP) [5]. Sensitive and efficient instruments are very important for residue analysis. Commonly used detection instruments include gas chromatography, liquid chromatography, liquid chromatography-mass spectrometry and gas chromatography-mass spectrometry. Some foreign scholars have used HLB solid phase extraction column to separate and enrich water samples in the environment, and the results of liquid chromatography analysis and detection show that under the best conditions, the recovery rate of this method is 65%~94%, and the relative standard deviation is less than 0.36%[6]. Other scholars used polybenzimidazole (PBI) as the extraction phase to establish a solid-phase microextraction and thermal desorption gas chromatography-mass spectrometry (spme/td-gc-ms) method for the detection of pesticides in environmental water. Under the optimal conditions, this method has a good linear range, with a relative recovery of 71%~104% and a relative standard deviation of 0.1%~8.7%. This method is applicable to tap water, pond water Determination of pesticide compounds in actual water samples such as river water [7]. An expert prepared molecularly imprinted polymer material with methyl propyl acid as monomer and xicaojin as template under different solvent volumes. The material was used to separate and enrich four herbicides in tobacco. The results of ultra-high performance liquid chromatography tandem mass spectrometry showed that the recovery rate of pesticides by this method was 84%~119%, and the relative standard deviation was 0.35%~10.12%[8].

This paper will screen pesticides in environmental water and sediments, find out the pesticides with prominent residues in this area as the research object, establish the analysis method of target pesticides, and evaluate the ecological risk to aquatic organisms, so as to provide data support for pesticide management in this region.

2. Impact and Detection of Environmental Pollutants

2.1. Effects of Environmental Pollutants on Plants

With the rapid development of industrial and agricultural production and the sharp increase of global population, chemical pollutants produced by human activities have an increasingly serious adverse impact on the environment on which human beings rely [9]. At present, inorganic pollutants represented by heavy metals and organic pollutants represented by organic pesticides and plasticizers have become the main pollutants in the environment, and are one of the research hotspots of soil ecosystem. These environmental pollutants can enter the soil through direct application, atmospheric sedimentation, waste disposal and industrial wastewater, which will not only destroy the ecosystem, but also can be enriched in crops or absorbed by non target organisms through soil migration, posing a threat to animal and human health [10].

Environmental pollutants can remain in plant leaves or soil through agricultural resource utilization, atmospheric sedimentation and other ways. The residual pollutants in the soil are easy to be absorbed and accumulated by non target organisms, thus realizing the migration and accumulation in different tissues of plants, affecting the quality and safety of agricultural products [11]. In recent years, China's agriculture has developed rapidly, and the application of pesticides has become an effective measure to control pests and improve the planting efficiency of crops. However, the long-term use of pesticides will cause serious harm to the local atmosphere and soil.

The metabolic process of environmental pollutants in plants is also a research hotspot. It is reported that pesticides can produce metabolites that are more toxic to non target organisms in the metabolic process. Compared with the parent substance, they have stronger activity, are more soluble in water, and are easier to migrate and accumulate in organisms, which will pose a certain threat to environmental pollution and food safety [12].

Pesticides are a kind of stress factors affecting crop growth, which can promote the growth of crops. The nonstandard use of pesticides leads to serious excessive pesticide residues in farmland and water environment, while pesticides in residual soil and water are easy to migrate to non target crops, which further has a certain impact on plant physiological metabolism and rhizosphere environment. However, at present, there is a lack of research on the mechanism of pesticide plant rhizosphere environment interaction [13].

2.2. Detection Technology of Pesticide Environmental Behavior

Agricultural production is inseparable from chemical pesticides. If the use of chemical pesticides is stopped, the production of grain, vegetables, fruits, etc. will be reduced in a large area. However, the environmental pollution caused by the massive use of pesticides is extremely serious, and even poses a threat to human survival. Therefore, the in-depth study of the environmental behavior of pesticides, the determination and control of pesticide residues, and the formulation of safe and reasonable application measures have become an important topic of international agricultural pharmaceutical research [14]. The second part of the evaluation and detection of the toxic effect and toxic effect of pesticides and their residues adopts advanced scientific technology and detection methods, which is conducive to the correct evaluation of the environmental behavior of pesticides, guiding the rational and safe use of pesticides, so as to effectively protect and control the harm of pesticides to the environment and human health [15].

(1) Isotope tracer technique

Radionuclide tracing technology has the characteristics of tracing, intuition, simplicity, trace and accuracy. Radioisotope labeled tracer technology is widely used in the study of pesticide absorption and distribution in the ecological environment, metabolic degradation (metabolic degradation pathway and product composition), biological efficacy of migration and transformation, and has unique technical advantages such as trace accuracy and traceability, which is difficult to be replaced by other non nuclear technologies. For example, in the study of pesticide metabolic fate, 14C labeled pesticides are usually used as tracers [16].

(2) Modern Chromatography and GC / MS technology

High performance liquid chromatography (HPLC) is a column chromatography technology with liquid as the mobile phase, which can be used to separate mixtures and quantify the proportion of each component. It can be qualitative according to the retention time of chromatographic peaks of standard samples and samples. It is an important separation and analysis technology widely used in the fields of chemistry, medicine, industry, agriculture, commodity inspection, legal inspection and other disciplines. HPLC has high separation efficiency, good selectivity, high detection sensitivity, automatic operation, is not limited by the volatility and thermal stability of the sample, and has a wide range of applications [17]. There are many kinds of mobile phases, and high separation efficiency can be achieved through the optimization of mobile phases. Chiral isomers of pesticides can be separated by using liquid chromatography chiral column to prepare single chiral compounds.

(3) Biological detection technology

Biological detection technology is a method to identify the efficacy of tested substances by using the specific reaction of organisms to tested substances, which can be used to detect the toxicity of samples. There are various forms of characterization of pesticide toxicity, and pesticide toxicity can be studied from multiple perspectives.

In the field of environmental assessment, there are some defects in the traditional physical and chemical test indicators. Therefore, it is necessary to find a suitable test organism to evaluate the indicators of environmental pollution. Biologists use scientific research on selected biological species to reveal a universal life phenomenon. This selected biological species is a model organism. In the process of scientific research, we should start with model organisms, first understand the relatively simple genome and physiological functions of lower organisms, and then further study the complex system of the human body on this basis [18].

3. Toxicity and Safety of Environmental Organisms

At present, the environmental quality standards only limit the residual concentration of individual pesticides, while there is no standard for the harm and risk of the residues of most commonly used pesticide additives to the ecological environment. In order to investigate the possible risks caused by pesticide residues in the environment, this chapter preliminarily evaluates the ecological risks caused by pesticide residues in river surface water and farmland soil according to the risk assessment method recommended by USEPA. The ecological risk assessment adopts the risk quotient method, which uses the measured pesticide residue concentration (MEC) in surface water and soil to compare with the corresponding NOEC respectively, so as to obtain the corresponding risk coefficient, and also combined with the corresponding grade standard to investigate the impact of pesticide residues on the ecological environment.

3.1. Sample Collection

The surface water samples are collected from the main rivers entering the sea in cities a and B. five representative sampling points are arranged respectively. The details of each sampling point are shown in the table. The surface water samples are collected with glass sampling bottles. The samples are transported back to the laboratory within 24 hours after collection, stored in a 4 ℃ refrigerator for standby, and the test is completed within a week.

Five samples were collected in the farmland of city a and city B respectively, with a total of 10 samples, each of which is not less than 2kg. The collected samples were packed in tin foil bags, numbered and taken back to the laboratory for treatment. Sampling shall be carried out at the depth of 0-20 cm. The sampling method adopts the grid point distribution method. Each soil sample shall be comprehensively mixed with 5 sample points. At the same time, the longitude and latitude coordinate information of each sampling point shall be recorded with GPS instrument. The sampling point shall be in the area with relatively stable terrain, and try to avoid foreign soil and new soil layers. All collected soil samples are naturally air dried, grinded, sieved through 20 meshes, and stored at low temperature.

3.2. Analysis Method

The risk quotient (RQ) method is used to evaluate the potential ecological risk caused by tspeon (n=6-29) residue. The calculation formula is as follows:

$$RQ_i = \frac{MEC_i}{NOEC_i} \tag{1}$$

$$NOEC = \frac{LC_{50} or EC_{50}}{AF} \tag{2}$$

Where RQI is the risk quotient of pollutant I; Meci (measured environmental concentration) is the environmental detected concentration of pollutant I; NOEC is the invalid stress concentration; AF is the evaluation factor, and this paper takes 1000. When rq<0.1, the pollutant has no potential ecological risk; When 1 > RQ ⩾ 0.1, it can be regarded as a medium risk, that is, long-term exposure of pollutants will bring potential harm to the ecological environment; When RQ ⩾ 1, the pollutants have high ecological risk.

4. Result Statistics and Analysis

4.1. Water Ecological Risk Assessment

Table 1. Water body risk assessment in city A

	A01	A02	A03	A04	A05
MEC(ng/L)	3.24	46.7	27.9	25.1	11.7
RQ	0.0002	0.0005	0.0003	0.0007	0.0001

Table 2. Ecological risk assessment of city B

	B01	B02	B03	B04	B05
MEC(ng/L)	40.92	101.17	37.56	29.07	47.83
RQ	0.0002	0.0005	0.0003	0.0007	0.0001

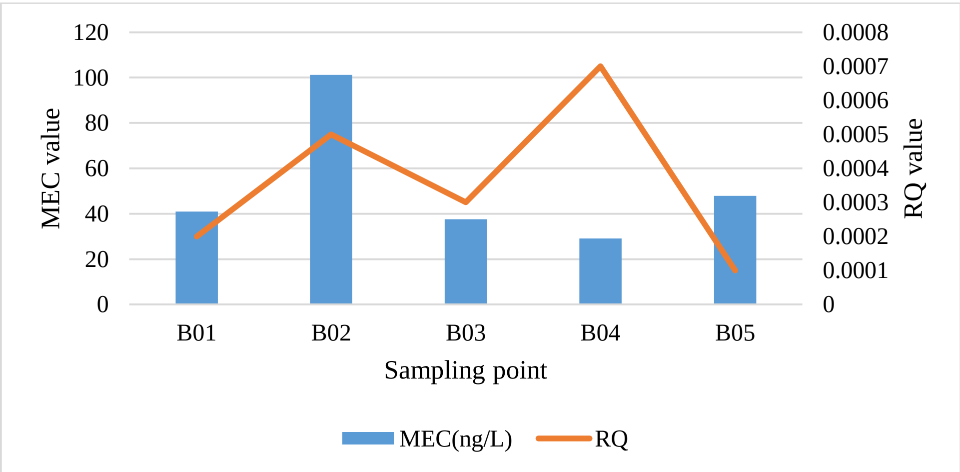

Figure 1. Water body risk assessment in city A

As shown in Table 1, table 2 and figure 1, the risk quotient values of the surface water of the main rivers entering the sea in city a and city B are calculated. Since the RQ values in the water body are far less than 0.1, there is no potential ecological risk of pesticide pollution in the water body currently investigated.

4.2. Soil Ecological Risk Assessment

Table 3. Soil ecological risk assessment in city a

	A11	A12	A13	A14	A15
MEC(ng/Kg)	104.52	41.75	12.64	15.49	7.54
RQ	0.0178	0.0235	0.0021	0.0546	0.0145

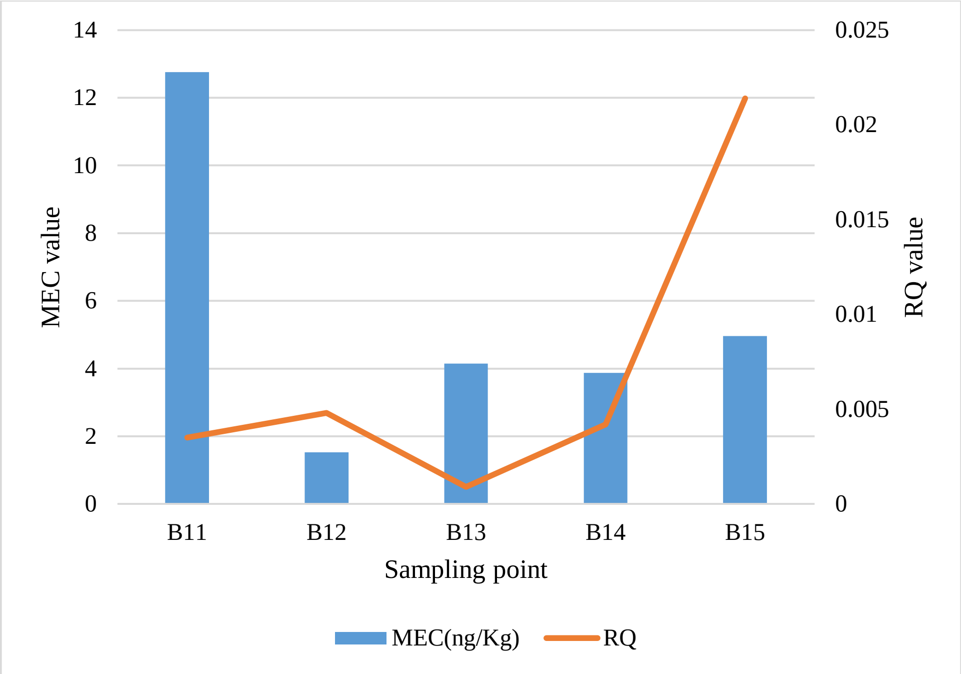

Figure 2. Statistics of soil ecological risk assessment in city B

According to Formula 1 and formula 2, the soil risk quotient value is calculated. The risk quotient values in the soils of the two places are shown in Table 3 and Figure 2 respectively. It can be seen that the RQ values of the surveyed soils in cities a and B are less than 0.1, indicating that there is no potential ecological risk in the soils of cities a and B at present.

5. Conclusion

Aiming at the lack of analytical methods for pesticide residues in water and soil matrix, this paper established analytical methods for pesticide residues in water and soil respectively, and conducted a preliminary ecological risk study in the sampling area. However, due to time constraints, there are some problems in this study, which need to be further studied. In this experiment, the pesticide situation in sediments was not studied. Therefore, it is necessary to further investigate the characteristics of pesticide residues in sediments and analyze the migration and transformation law of pesticides between sediments and water bodies.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Waheed S, Halsall C, Sweetman A J, et al. Pesticides contaminated dust exposure, risk diagnosis and exposure markers in occupational and residential settings of Lahore, Pakistan. Environmental Toxicology & Pharmacology, 2017, 56(DEC.):375-382. https://doi.org/10.1016/j.etap.2017.11.003

[2] Leonardo T, Birnbaum L S. When enough data are not enough to enact policy: The failure to ban chlorpyrifos. Plos Biology, 2017, 15(12):e2003671. https://doi.org/10.1371/journal.pbio.2003671

[3] Omeroglu P Y, Ambrus A, Boyaciogtu D. Uncertainty of pesticide residue concentration determined from ordinary and weighted linear regression curve. Food additives & contaminants, 2018, 35(7):1324-1339.

[4] Efsa E. Scientific support for preparing an EU position in the 50th Session of the Codex Committee on Pesticide Residues (CCPR). EFSA Journal, 2018, 16(7). https://doi.org/10.2903/j.efsa.2018.5306

[5] Efsa E F S A, Brancato A, Brocca D, et al. Review of the existing maximum residue levels for 2,5‐dichlorobenzoic acid methylester according to Article 12 of Regulation (EC) No396/2005. EFSA Journal, 2018, 16(6). https://doi.org/10.2903/j.efsa.2018.5331

[6] Roussev M, Lehotay S J, Pollaehne J. Cryogenic Sample Processing with Liquid Nitrogen for Effective and Efficient Monitoring of Pesticide Residues in Foods and Feeds. Journal of Agricultural and Food Chemistry, 2019, 67(33):9203-9209. https://doi.org/10.1021/acs.jafc.9b04006

[7] Shuja A, Shafi H, Abid A I, et al. Determination of Pesticide Residues Using QuEChERS Extraction with Inert GC-MSD Analytical Technique and Application on Seasonal Fruits and Vegetables in Pakistan. Open Access Library Journal, 2020, 9(3):13.

[8] Varol M, Sunbul M R. Organochlorine pesticide, antibiotic and heavy metal residues in mussel, crayfish and fish species from a reservoir on the Euphrates River, Turkey. Environmental Pollution, 2017, 230(nov.):311-319.

[9] Afaf. A, Abd A, Asely A E, et al. Impact of pyrethroids and organochlorine pesticides residue on IGF-1 and CYP1A genes expression and muscle protein patterns of cultured Mugil capito. Ecotoxicology and Environmental Safety, 2020, 188(Jan.):109876.1-109876.9. https://doi.org/10.1016/j.ecoenv.2019.109876

[10] Breysse N, Vial G, Pattingre L, et al. Impact of a proposed revision of the IESTI equation on the acute risk assessment conducted when setting maximum residue levels (MRLs) in the European Union (EU): A case study. J Environ Sci Health B, 2018, 53(4-6):352-365.

[11] Maestroni B, Besil N, Rezende S, et al. Method optimization and validation for multi-class residue analysis in turmeric. Food Control, 2020, 121(2):107579.

[12] Czaja K, P Struciński, Korcz W, et al. Alternative toxicological methods for establishing residue definitions applied for dietary risk assessment of pesticides in the European Union. Food and Chemical Toxicology, 2020, 137(8):111120. https://doi.org/10.1016/j.fct.2020.111120

[13] Megawati, Sulaiman M I, Zakaria S. Detection of organophosphate pesticide residues of chili (capsicum annuum l.) in different seasons in Aceh province. IOP Conference Series: Earth and Environmental Science, 2020, 922(1):012043 (8pp).

[14] Alcantara D B, Fernandes T, Nascimento H O, et al. Diagnostic detection systems and QuEChERS methods for multiclass pesticide analyses in different types of fruits: An overview from the last decade. Food Chemistry, 2019, 298(NOV.15):124958.1-124958.14.

[15] Srivastava A, Rai S, Sonker A K, et al. Simultaneous determination of multiclass pesticide residues in human plasma using a mini QuEChERS method. Analytical & Bioanalytical Chemistry, 2017, 409(15):3757-3765. https://doi.org/10.1007/s00216-017-0317-7

[16] Beneta A, Pavlovic D M, Perisa I, et al. Multiresidue GC-MS/MS pesticide analysis for evaluation of tea and herbal infusion safety. International journal of environmental analytical chemistry, 2018, 98(11-15):987-1004.

[17] Pena A, Delgado-Moreno L, Rodriguez-Liebana J A. A review of the impact of wastewater on the fate of pesticides in soils: Effect of some soil and solution properties. The Science of the Total Environment, 2020, 718(May20):134468.1-134468.21. https://doi.org/10.1016/j.scitotenv.2019.134468

[18] Bortoli S, Coumoul X. Impact des pesticides sur la santé humaine. Pratiques en Nutrition, 2018, 14(53):18-24. https://doi.org/10.1016/j.pranut.2017.12.005