

Preplanned Studies

Occurrence and Risk Assessment of Typical Endocrine-Disrupting Chemicals in Surface and Drinking Water Across Four River Basins — Henan Province, China, 2025

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Summary

What is already known about this topic?

Bisphenols and per- and polyfluoroalkyl substances (PFASs) are endocrine-disrupting chemicals found in aquatic ecosystems. Henan, a critical water conveyance region within the South-to-North Water Diversion Project, encompasses four river basins characterized by complex hydrological conditions. However, systematic monitoring of contaminant levels remains insufficient.

What is added by this report?

This study identified key priority pollutants and highlighted the dominance of short-chain PFASs in the region.

What are the implications for public health practice?

These baseline data address gaps in existing knowledge on emerging pollutants omitted from GB 5749-2022, thereby providing critical scientific evidence to guide the revision of national drinking water standards, strengthen watershed pollution control, and safeguard public health and ecotoxicological integrity.

ABSTRACT

Introduction: Bisphenols (BPs) and per- and polyfluoroalkyl substances (PFASs) in aquatic environments have attracted significant research attention. Assessing their abundance in surface and drinking water across the Yangtze, Yellow, Huai, and Hai River Basins in Henan Province is crucial for exploring exposure and toxicity-related risks, thereby guiding future mitigation strategies.

Methods: Surface and drinking water samples ($n=191$) were collected and analyzed in October 2025 for health and ecotoxicological risk assessments.

Results: Four BPs and 11 PFASs were detected in Henan Province, and bisphenol A (BPA) and short-chain PFASs were identified as the predominant pollutants. The Yangtze River Basin had the highest

average total concentrations of endocrine-disrupting chemicals (Σ EDCs). Hazard quotients were consistently higher for children than for adults. BPA poses a high aquatic ecological risk, whereas PFBS demonstrates a stronger potential for human non-carcinogenic risks through drinking water exposure.

Conclusion: Continuous monitoring of EDCs, such as BPA, in the Yangtze River Basin is essential for comprehensively evaluating their associated impacts on aquatic environments. Enhanced surveillance of priority pollutants in major river basins is recommended to safeguard drinking water for vulnerable populations, particularly children.

Endocrine-disrupting chemicals (EDCs), such as bisphenols (BPs) and per- and polyfluoroalkyl substances (PFASs), are exogenous organic compounds that interfere with hormonal physiology and endocrine system functions (*1*). Previous studies have highlighted varying EDC levels in drinking water across countries (*2*). However, existing research on BPs and PFASs in major river basins, such as the Yangtze (*3*) and Haihe (*4*) Rivers, mainly focuses on specific basins or compounds, without accounting for the water supply chain.

Henan Province spans the Yellow, Huai, Yangtze, and Hai River Basins. It is both an important water source and receiving region for the South-to-North Water Diversion Project. Nevertheless, no studies have documented the changing BP and PFAS concentrations during drinking water treatment across these basins. This study explored the concentrations of 4 BPs and 11 PFASs, and their associated risks, in 4 major river basins of Henan Province.

A total of 191 samples, including 46 source, 46 treated, 51 tap, and 48 surface water samples, were collected from 16 counties (cities and districts) across 4 river basins ([Supplementary Table S1](#), available at

<https://weekly.chinacdc.cn>) in September–November 2025. Sampling sites were selected based on the hydrological characteristics of Henan Province, covering the upper, middle, and lower reaches of the basins. Sampling covered water sources, water treatment plants, pipe network terminals, and densely populated areas. Three surface, three source, three treated drinking water, and three tap water samples were collected from each administrative region.

Samples were analyzed at the Henan Center for Disease Control and Prevention using liquid chromatography–mass spectrometry, following the internal standard method. Blank and recovery experiments were performed for quality control. The Wilcoxon rank-sum test was used to assess differences among river basins. All plots were generated and analyzed using CNSknowall (<https://cnsknowall.com>), a web service for data analysis and visualization. EDC analysis plots were generated using this platform for data analysis and visualization.

Non-carcinogenic risks associated with EDCs were evaluated in both adults and children using the health risk assessment model recommended by the U.S. Environmental Protection Agency (USEPA) (5). The risk quotient (*RQ*) approach has been used to evaluate

the potential impacts of EDCs on aquatic organisms (6). Reference doses, acute toxicity parameters, and data are presented in [Supplementary Tables S2 and S3](#) (available at <https://weekly.chinacdc.cn>).

Bisphenol AF (BPAF), bisphenol A (BPA), and perfluorobutane sulfonate (PFBS) were the most frequently detected EDCs, followed by perfluorobutanoic acid (PFBA) and bisphenol S (BPS). Detection rates for other EDCs remained below 20%. BPAF, BPA, PFBS, PFBA, and BPS concentrations ranged from not detected (nd) to 6.4 ng/L, nd to 646.0 ng/L, nd to 57.1 ng/L, nd to 27.0 ng/L, and nd to 17.8 ng/L, respectively. The Anderson–Darling test used to evaluate the normality of the concentration datasets for the 15 EDCs demonstrated that the data followed non-normal distributions (Table 1). In contrast, perfluorohexanoic acid, perfluorononanoic acid, perfluorodecanoic acid, and perfluoroheptanoic acid were not detected in any samples. BPA was the predominant pollutant among BPs, whereas PFBS and PFBA, both short-chain PFASs, were the dominant congeners.

The Yangtze River Basin exhibited the highest average Σ EDCs values, followed by the Huai and Hai River Basins. The lowest average Σ EDC concentration

TABLE 1. Detection rates and concentrations of endocrine-disrupting chemicals in the collected water samples in China, 2025.

EDCs		Detection rate (%)	Mean (ng/L)	Max (ng/L)	P25 (ng/L)	Median (ng/L)	P75 (ng/L)	P90 (ng/L)
BPs	BPA	52.2	20.5	646.0	0.45	1.15	8.28	43.0
	BPS	25.6	0.7	17.8	0.1	0.1	0.153	1.046
	BPAF	57.0	0.3	6.4	0.008	0.056	0.267	0.822
	TBBPA	9.7	0.6	49.2	0.05	0.05	0.05	0.05
PFASs	PFBA	28.0	2.0	27.0	0.9	0.9	3.36	9.62
	PFPeA	0.5	1.1	41.1	0.9	0.9	0.9	0.9
	PFHxA	0	nd	nd	nd	nd	nd	nd
	PFHpA	0	nd	nd	nd	nd	nd	nd
	PFOA	3.9	2.5	53.1	2.5	2.5	2.5	2.5
	PFNA	0	nd	nd	nd	nd	nd	nd
	PFDA	0	nd	nd	nd	nd	nd	nd
	PFBS	37.2	1.5	57.1	0.1	0.1	1.02	3.14
	PFHxS	6.8	0.2	3.4	0.1	0.1	0.1	0.1
	PFOS	15.5	0.6	6.6	0.35	0.35	0.35	1.23
	PFHpS	1.4	0.1	0.8	0.05	0.05	0.05	0.05

Note: Concentrations of undetected samples were assigned as half the limit of detection.

Abbreviation: BPs=bisphenols; PFASs=per- and polyfluoroalkyl substances; BPA=bisphenol A; BPS=bisphenol S; BPAF=bisphenol AF; TBBPA=tetrabromobisphenol A; PFBA=perfluorobutanoic acid; PFPeA=perfluoropentanoic acid; PFHxA=perfluorohexanoic acid; PFHpA=perfluoroheptanoic acid; PFOA=perfluorooctanoic acid; PFNA=perfluorononanoic acid; PFDA=perfluorodecanoic acid; PFBS=perfluorobutane sulfonate; PFHxS=perfluorohexanesulfonic acid; PFOS=perfluorooctanesulfonic acid; PFHpS=perfluoroheptanesulfonic acid; nd=not detected.

was observed in the Yellow River Basin (Figure 1A). The BPA, BPS, BPAF, and PFBA concentrations in the Yangtze River basin were significantly higher than those in the Hai River Basin ($P<0.05$). Moreover, significantly higher concentrations of BPA and PFBA were observed in the Yangtze River basin than in the Huai River basin ($P<0.05$). In contrast, PFBS concentrations did not vary significantly among the

four basins ($P>0.05$) (Figure 1B).

The Σ BP concentrations in surface water samples showed the widest range (nd–687.0 ng/L), exceeding all other samples. The Σ BP concentrations were markedly lower in both treated and tap water samples. The Σ PFAS concentrations in surface water samples ranged from nd to 85.4 ng/L. The concentrations of BPs and PFASs in surface water were significantly

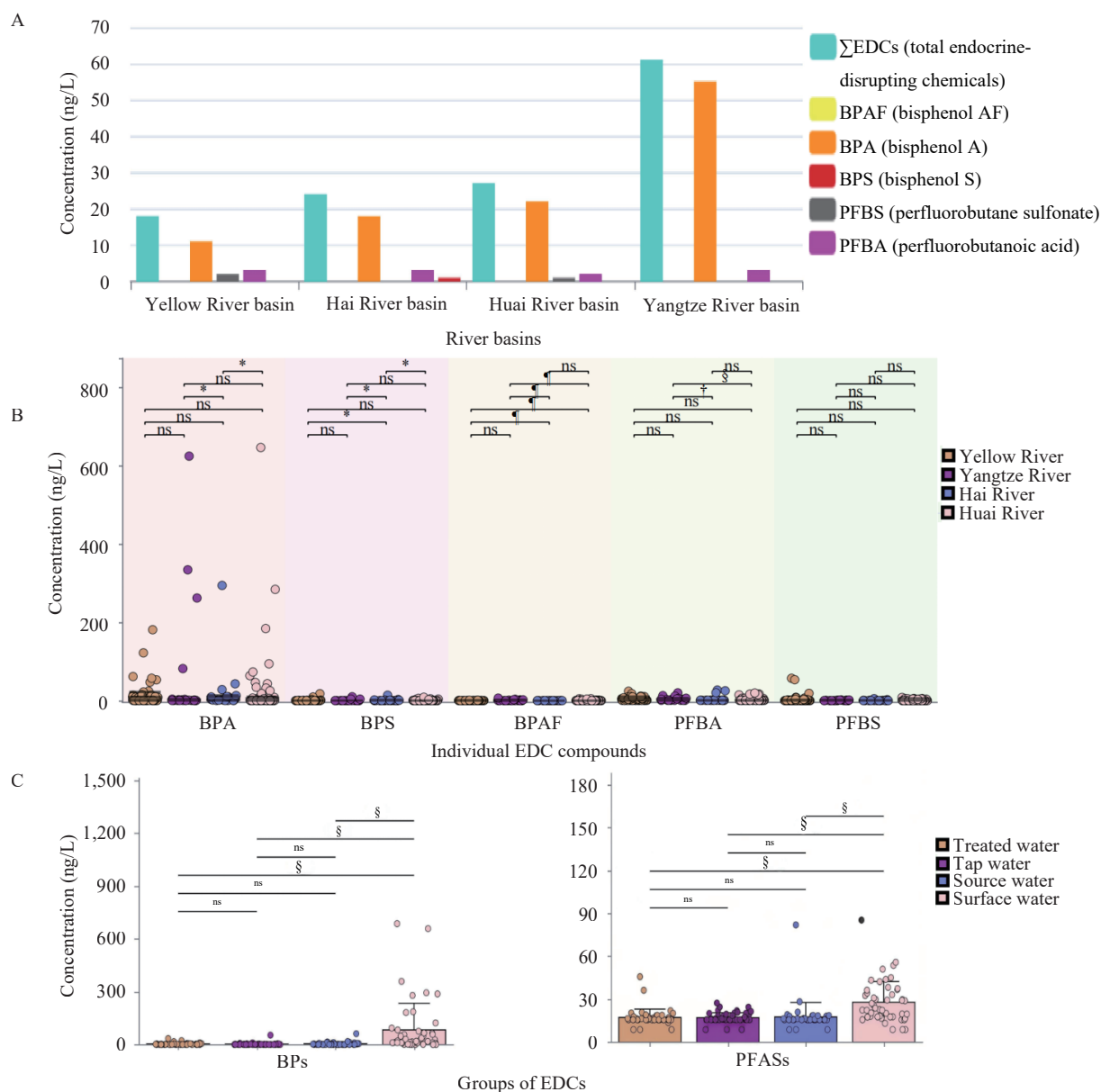


FIGURE 1. EDCs concentrations in four major river basins in Henan Province, 2025. (A) Concentrations of EDCs in different river basins; (B) Distribution of individual EDCs among river basins; (C) Concentrations of different EDC groups in different water sample types.

Note: ns represents no statistically significant differences.

Abbreviation: EDCs=endocrine-disrupting chemicals; BPA=bisphenol A; BPS=bisphenol S; BPAF=bisphenol AF; PFBA=perfluorobutanoic acid; PFBS=perfluorobutane sulfonate.

* $P<0.05$, † $P<0.01$, § $P<0.005$, ¶ $P<0.001$; ($P>0.05$).

higher than those in source, treated, and tap water ($P<0.005$) (Figure 1C). These findings suggest that BPs and PFASs exhibit pronounced environmental persistence, reducing the efficacy of conventional drinking water treatment.

Due to the absence of USEPA cancer slope factors, this investigation focused exclusively on non-carcinogenic risk assessments. The hazard quotients (HQs) of the five EDCs (BPA, BPS, BPAF, PFBA, and PFBS) with detection frequencies $>20\%$ were calculated (Figure 2A). The HQs of all EDCs were below 1, with a maximum of 1.9×10^{-2} , suggesting that EDCs are unlikely to pose non-carcinogenic risks. The most serious non-carcinogenic risk was observed in the Yellow River Basin, where the maximum HQs reached

5.4×10^{-3} for adults and 1.9×10^{-2} for children, corresponding to a PFBS concentration of 57.1 ng/L. Moreover, the maximum HQs in the Yangtze River Basin reached 6.0×10^{-4} and 2.0×10^{-3} for adults and children, respectively, corresponding to a PFBS concentration of 20.0 ng/L. Conversely, the associated human health risks were relatively low in the Huai and Hai River Basins. Across all basins, HQs were consistently higher in children than adults, indicating greater vulnerability to five EDCs. Importantly, all HQs for adults and children were far below the threshold of 1.0, suggesting negligible health risks associated with EDCs in the studied basins.

The distributions of the ecotoxicological RQ values associated with the five dominant EDCs in the surface

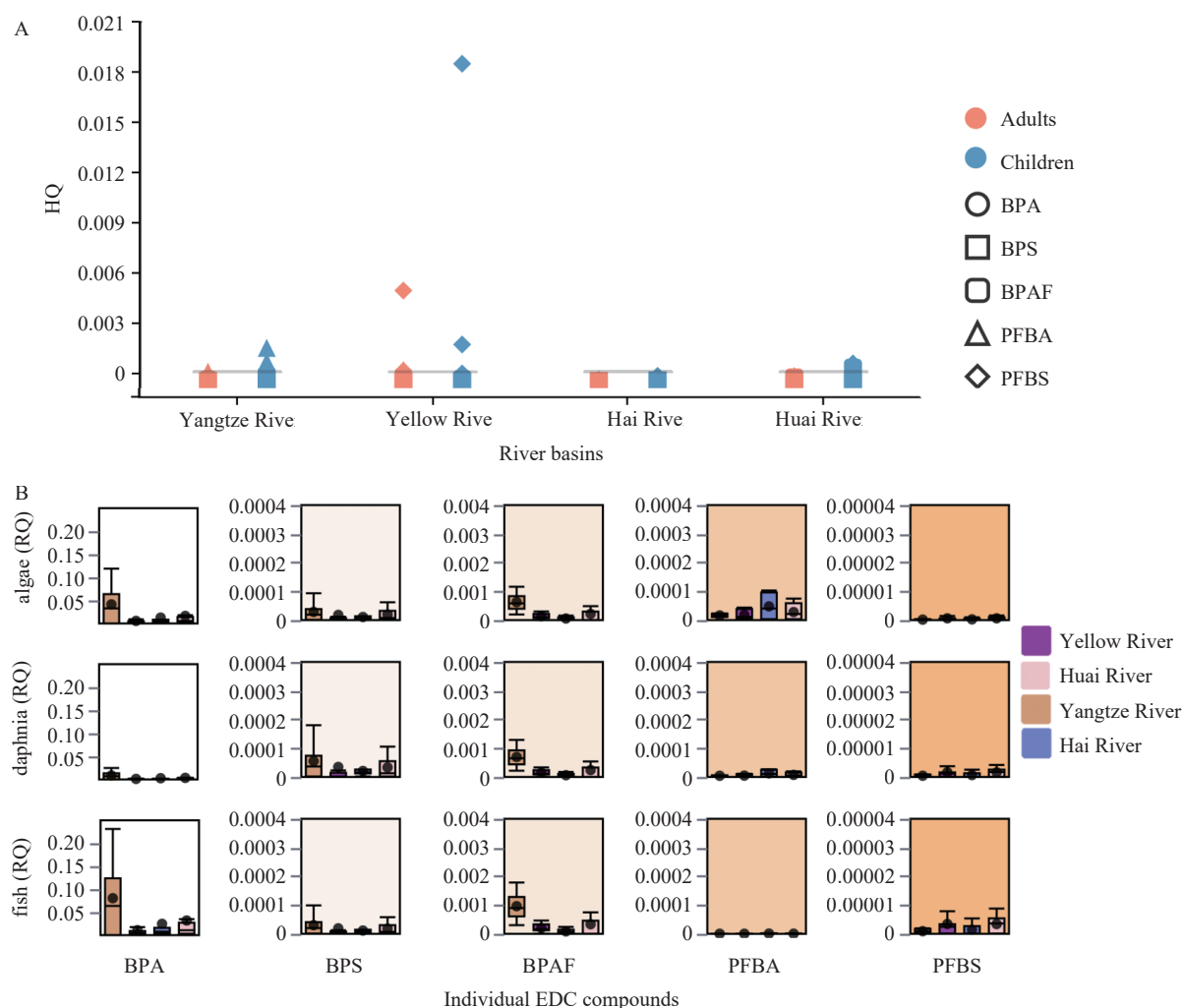


FIGURE 2. Risk assessment results of five EDCs in China, 2025. (A) Non-carcinogenic risk assessment results of five EDCs in drinking water for children and adults in different river basins; (B) Ecotoxicological risk assessment results of five EDCs in surface water at three trophic levels.

Abbreviation: EDCs=endocrine-disrupting chemicals; BPA=bisphenol A; BPS=bisphenol S; BPAF=bisphenol AF; PFBA=perfluorobutanoic acid; PFBS=perfluorobutane sulfonate.

waters of four river basins were determined across three trophic levels (algae, *Daphnia*, and fish) (Figure 2B). *RQs* associated with BPs exceeded those associated with PFASs. Within the Yangtze River, the highest average *RQs* for BPA, BPS, and BPAF reached 4.3×10^{-2} , 3.8×10^{-5} , and 7.6×10^{-4} , respectively. Across all trophic levels, PFBA consistently exhibited higher ecotoxicological *RQs* than PFBS. The Haihe River Basin exhibited the highest average PFBA-associated *RQ*, reaching 1.0×10^{-4} , surpassing other basins. Tanghe County (a city in the Yangtze River Basin) had the highest BPA-associated *RQs*, 0.010 to 0.231. The remaining EDCs showed relatively low *RQs* (<1) suggesting that the ecotoxicological risks of surface water EDCs are acceptable.

DISCUSSION

This is the first comprehensive study of 15 EDCs coupled with a dual health–ecological assessment across Henan Province. The data were highly representative and covered the entire study area. The investigated BPs and PFASs represent the major pollutants threatening the source waters of the South-to-North Water Diversion Project. The findings provide critical evidence for developing and strengthening protective measures to ensure the Project's long-term sustainability.

The results identified short-chain PFAS (e.g., PFBS and PFBA) and BPA as the dominant pollutants in the study region. Notably, BPA presents higher ecological risks than PFBS, whereas PFBS poses greater human non-carcinogenic health risks through drinking water exposure. Industrial activities along river basins generate copious BPs and PFASs (7). The open burning of dumped waste and landfill leachate can release EDCs contained in plastic waste into the surrounding environment (8), whereas food packaging and domestic sewage are stable sources of EDCs (9).

PFASs are chemically stable, highly recalcitrant to degradation, and highly mobile over long distances, making them difficult to eliminate with conventional water treatment (10). Although conventional treatments can effectively eliminate BPs, source reduction remains essential for reducing treatment loads because source control is inherently more efficient than terminal remediation. Therefore, the advancement of green material substitution coupled with the enforcement of stricter emission controls in EDC-related industries is strongly recommended to alleviate ecological and public health risks. As a critical

water-supply basin for the South-to-North Water Diversion Project, local authorities should strictly supervise industrial emissions and incorporate short-chain PFAS and BPA into routine monitoring protocols.

This study confirmed that children face significantly greater health risks than adults. Henan Province should prioritize addressing the hazards of prolonged low-dose exposure in children. Moreover, efforts to disseminate water safety knowledge should be intensified, with an emphasis on educating residents and safeguarding children. Inspecting water quality in schools and kindergartens should be prioritized.

Under Drinking Water Quality Standards (GB 5749-2022), the maximum permissible concentrations are 10.0 µg/L for BPA, 0.08 µg/L for PFOA, and 0.04 µg/L for PFOS. However, no domestic regulatory thresholds have been established for other EDCs. By contrast, in April 2024 the USEPA promulgated markedly stricter limits at 4.0 ng/L for both PFOA and PFOS, and 1.0 ng/L for PFBS. However, no federal limits have been established for BPA levels in drinking water.

The findings in this report are subject to one limitation. Because sampling was restricted to a single season, data from different periods could not be obtained, preventing the assessment of seasonal fluctuations in pollutant concentrations and potentially introducing bias.

As for recommendations, stricter pollution control measures are imperative to safeguard drinking water sources in the Yangtze River Basin and long-term monitoring of emerging pollutants is necessary. Additional protection should be prioritized for vulnerable groups, particularly children. Collectively, these measures can substantially improve drinking water safety across provinces.

Conflicts of interest: No conflicts of interest.

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SUPPLEMENTARY MATERIALS

Instrument Parameters

Mass spectral analysis was conducted using a QTRAP 6500 linear ion trap quadrupole LC-MS/MS spectrometer (AB SCIEX, USA), equipped with an ESI probe. The LC-MS/MS system equipped with a 30A system (SHIMADZU, JAPAN) used a Waters ACQUITY UPLCTM BEH C₁₈ column (100 mm × 2.1 mm, 1.7 μm).

Formulas for Risk Assessment

Human Health Risk Assessment: The carcinogenic and non-carcinogenic risks of EDCs for adults and children were quantified using Equations 1 and 2 based on the health risk assessment model recommended by the USEPA (1). The hazard quotient (*HQ*) was applied to assess the non-carcinogenic risk to humans via the direct ingestion of surface water used as drinking water, whereas alternative exposure pathways (e.g., dermal contact) were not considered.

$$HQ = CDI / RfD \quad (1)$$

where *CDI* denotes chronic daily intake, representing the estimated human exposure to contaminants through ingestion [mg/(kg.day)] and was calculated using Equation 2; *RfD* is the reference dose [mg/(kg.day)], defined as the oral exposure threshold for a given contaminant, and was obtained from the Regional Screening Level Summary Table of the USEPA:

$$CDI_i = \frac{C \times IR_i \times EF_i \times ED_i}{BW_i \times AT} \quad (2)$$

where *C* denotes the measured concentration of contaminants in each water sample (mg/L). For samples with concentrations below the limit of detection (LOD), values were assigned as one-half LOD for subsequent calculation; *IR_i* represents the water ingestion rate (1 L/day and 2 L/day for children and adults, respectively) (L/day); *EF_i* is the exposure frequency (365 days/year for both ages); *ED_i* represents exposure duration (6 years for children and 70 years for adults), *BW_i* denotes body weight of the exposed person (10 kg for children and 70 kg for adults), and *AT* indicates average lifespan (2,190 and 25,550 days for children and adults, respectively). An *HQ* greater than 1 indicates a non-tolerable exposure level, suggesting that the compound in question is likely to cause adverse effects. Conversely, when the *HQ* < 1, adverse effects are unlikely.

Ecotoxicological Risk Assessment: The risk quotient (*RQ*) was employed to assess the potential impacts of EDCs on aquatic organisms and to predict the extent of the harm they pose to both aquatic organisms and humans (2). Ecotoxicological risk assessments were conducted using Equations 3 and 4. In this study, the ecological *RQs* of 15 EDCs were calculated across 3 categories of aquatic organisms (algae, *Daphnia*, and fish) based on 48 surface water samples.

$$RQ = MEC / PNEC \quad (3)$$

$$PNEC = EC_{50} / AF \quad (4)$$

where *MEC* denotes the measured environmental concentration, mg/L; *PNEC* represents the predicted no-effect concentration of the substance, mg/L; *EC₅₀* denotes the median effect concentration of the substance on organisms, obtained through a literature review, mg/L; and *AF* is the assessment factor, adopting the recommended value of 1,000 specified in the EU Water Framework Directive. The risk assessment was divided into four levels: minor risk (*RQ* ≤ 0.01), low risk (0.01 < *RQ* ≤ 0.1), moderate risk (0.1 < *RQ* ≤ 0.5), and high risk (*RQ* > 0.5).

SUPPLEMENTARY TABLE S1. Average concentrations of endocrine-disrupting chemicals in the different administrative regions of the study area in China, 2025.

River Basins	Administrative Region	Mean concentration (ng/L)
Yellow River Basin	Lingbao	27.0
	Gongyi	16.6
	Wuzhi	4.5
	Luoning	5.4
	Pingyuan	10.2
	Taiqian	39.2
Huai River Basin	Lankao	5.7
	Suiping	33.5
	Chuanhui	18.2
	Shenqiu	17.4
	Wuyang	2.5
	Liangyuan	78.6
Yangtze River Basin	Xichuan	10.2
	Tanghe	103.2
Hai River Basin	Linzhou	34.0
	Junxian	11.0

SUPPLEMENTARY TABLE S2. Reference doses (*RfD*s) of five endocrine-disrupting chemicals for human health risk calculation.

EDCs	CAS	<i>RfD</i> [mg/(kg·d)]	Sources
BPAF	1478-61-1	0.0006	EPA Database-Calibrated Assessment Product (DCAP)
BPA	80-05-7	0.05	EPA Integrated Risk Information System (IRIS)
PFBS	375-73-5	0.0003	EPA Provisional Peer-Reviewed Toxicity Values (PPRTVs)
PFBA	375-22-4	0.001	EPA IRIS
BPS	80-09-1	0.0059	EPA DCAP

Note: All *RfD* values were retrieved from the publicly available USEPA IRIS, DCAP, and PPRTVs online databases for 2026.

Abbreviation: BPA=bisphenol A; BPS=bisphenol S; BPAF=bisphenol AF; PFBA=perfluorobutanoic acid; PFBS=perfluorobutane sulfonate; *RfD*=reference dose; EDCs=endocrine-disrupting chemicals.

SUPPLEMENTARY TABLE S3. Acute toxicity data (*EC*₅₀) of five EDCs and corresponding references.

EDCs	Algae	<i>EC</i> ₅₀ (mg/L) <i>Daphnia</i>	Fish	References
BPA	5.25	25.1	2.7	(3–5)
BPS	106	55	100.1	(6–8)
BPAF	3.0	2.7	1.95	(9–11)
PFBA	262.2	1,006	13,795	(12–14)
PFBS	5,023	1937	921.9	(15–16,12)

Abbreviation: *EC*₅₀=half-maximal effective concentration; BPA=bisphenol A; BPS=bisphenol S; BPAF=bisphenol AF; PFBA=perfluorobutanoic acid; PFBS=perfluorobutane sulfonate.

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