

水环境中双酚A污染及其对鱼类的毒性研究进展

许海^{1,2}, 杨明¹, 吴明红¹

(1. 上海大学环境与化学工程学院, 上海200444; 2. 江苏大学环境学院, 江苏镇江212013)

Bisphenol A in the Aquatic Environment and Its Toxic Effects on Fish

XU Hai^{1,2}, YANG Ming¹, WU Ming-hong¹

- [摘要](#)
- [参考文献](#)
- [相关文章](#)

Download: [PDF \(858KB\)](#) | [HTML \(1KB\)](#) | [Export: BibTeX or EndNote \(RIS\)](#) | [Supporting Info](#)

摘要 双酚A(bisphenol A, BPA) 是公认的环境内分泌干扰物, 广泛存在于水环境中, 并对水生生态系统的安全造成潜在威胁. 结合BPA污染和毒理学的相关研究成果, 综述了BPA 在不同水体中的污染现状, 及其对鱼类的内分泌干扰作用、生殖毒性、免疫毒性和发育神经毒性. 在此基础上, 进一步指出了研究BPA 的重要性和今后的研究方向.

关键词: [双酚A](#) [内分泌干扰](#) [免疫毒性](#) [神经毒性](#) [毒理学](#)

Abstract: Bisphenol A (BPA) is a well-known endocrine-disrupting chemical present in aquatic environments, and has a potential threat on the aquatic ecosystem safety. Based on the studies, this paper reviews the literature concerning contamination status of BPA in various water bodies and its endocrine-disruptive, reproductive, immunological and neurotoxic effects on fish, shows the importance of the BPA study and suggests directions of the future research.

Keywords: [bisphenol A \(BPA\)](#), [endocrine disruption](#), [immunotoxicity](#), [neurotoxicity](#), [toxicology](#)

基金资助:

国家自然科学基金资助项目(31100376, 11025526, 41173120)

作者简介: 杨明(1979—), 女, 副研究员, 博士, 研究方向为生态毒理学. E-mail: mingyang@shu.edu.cn

引用本文:

.水环境中双酚A污染及其对鱼类的毒性研究进展[J] 上海大学学报(自然科学版), 2013,V19(4): 429-436

.Bisphenol A in the Aquatic Environment and Its Toxic Effects on FishXU[J] J.Shanghai University (Natural Science Edition), 2013,V19(4): 429-436
链接本文:<http://www.journal.shu.edu.cn//CN/> 或 <http://www.journal.shu.edu.cn//CN/Y2013/V19/I4/429>

- [1] Burridge E. Chemical profile: bisphenol A [N/OL].
/13/9162868/Chemical-profile-bisphenol-A.html.
- [2] 肖云波, 于海琴. 双酚A在环境中迁移转化的研究进
山西建筑, 2007, 33(6): 180-182.
- [3] 张想竹, 侯绍刚, 吴明书. 双酚A 的环境行为研究进
安阳工学院学报, 2006, 20(2): 10-17.
- [4] 邓红梅, 梁春营, 陈永亨. 水环境中双酚A的污染及其生
Fuerhacker M. Bisphenol A emission factors from
industrial sources and elimination rates in a sewage
treatment plant [J]. Water Science and Technology,

Service

- ▶ [把本文推荐给朋友](#)
- ▶ [加入我的书架](#)
- ▶ [加入引用管理器](#)
- ▶ [Email Alert](#)
- ▶ [RSS](#)

作者相关文章

[11] 03, 47(10): 117-122.

[12] Yamamoto T, Yasuhara A, Shiraishi H, et al.

[13] Bisphenol A in hazardous waste landfill leachates [J].

[14] Chemosphere, 2001, 42(4): 415-418.

[15] Zha J, Wang Z. Acute and early life stage toxicity

[16] of industrial effluent on Japanese medaka (*Oryzias*

[17] *latipes*) [J]. Science of the Total Environment, 2006,

[18] 7(1/2/3): 112-119.

[19] Le H H, Carlson E M, Chua J P, et al. Bisphenol

[20] A is released from polycarbonate drinking bottles and

[21] mimics the neurotoxic actions of estrogen in developing

[22] cerebellar neurons [J]. Toxicology Letters, 2008,

[23] 6(2): 149-156.

[24] Jin X, Jiang G, Huang G, et al. Determination

[25] of 4-tert-octylphenol, 4-nonylphenol and bisphenol A

[26] in surface waters from the Haihe River in Tianjin by

[27] gas chromatography-mass spectrometry with selected

[28] ion monitoring [J]. Chemosphere, 2004, 56(11): 1113-

[29] 1119.

[30] Peng X Z, Yu Y J, Tang C M, et al. Occurrence of

[31] steroid estrogens, endocrine-disrupting phenols, and

[32] acid pharmaceutical residues in urban riverine water

[33] of the Pearl River Delta, South China [J]. Science of

[34] the Total Environment, 2008, 397(1/2/3): 158-166.

[35] Gong J, Ran Y, Chen D Y, et al. Occurrence and

[36] environmental risk of endocrine-disrupting chemicals

[37] in surface waters of the Pearl River, South China [J].

[38] Environmental Monitoring and Assessment, 2009,

[39] 6(1/2/3/4): 199-210.

[40] Xue X, Wu F, Zhang X, et al. Occurrence of

[41] endocrine disrupting compounds in rivers and lakes

[42] of Wuhan city, China [J]. Fresenius Environmental

[43] Bulletin, 2008, 17(2): 203-210.

[44] Yang F X, Xu Y, Pfister G, et al. Nonylphenol,

[45] bisphenol-A and DDTs in Lake Donghu, China [J].

[46] Fresenius Environmental Bulletin, 2005, 14(3): 173-

[47] 180.

[48] Fu M, Li Z, Gao H. Distribution characteristics of

[49] nonylphenol in Jiaozhou Bay of Qingdao and its adjacent

[50] rivers [J]. Chemosphere, 2007, 69(7): 1009-1016.

[51] Gong J, Ran Y, Chen D Y, et al. Occurrence of

[52] endocrine-disrupting chemicals in riverine sediments

[53] from the Pearl River Delta, China [J]. Marine Pollution

[54] Bulletin, 2011, 63(5): 556-563.

[55] Hashimoto S, Horiuchi A, Yoshimoto T, et

[56] al. Horizontal and vertical distribution of estrogenic

[57] activities in sediments and waters from Tokyo Bay,

[58] Japan [J]. Archives of Environmental Contamination
[59] and Toxicology, 2005, 48(2): 209-216.

[60] Khim J S, Lee K T, Kannan K, et al. Trace organic
[61] contaminants in sediment and water from Ulsan Bay
[62] and its vicinity, Korea [J]. Archives of Environmental
[63] Contamination and Toxicology, 2001, 40(2): 141-150.

[64] Stachel B, Ehrhorn U, Heemken O P, et al.
[65] Xenoestrogens in the River Elbe and its tributaries
[66] Environmental Pollution, 2003, 124(3):
[67] 7-507.

[68] Klecka G M, Staples C A, Clark K E, et al.
[69] Exposure analysis of bisphenol A in surface water systems
[70] in North America and Europe [J]. Environmental
[71] Science & Technology, 2009, 43(16): 6145-6150.

[72] Staples C A, Dorn P B, Klecka G M, et al. A
[73] review of the environmental fate, effects, and exposures
[74] of bisphenol A [J]. Chemosphere, 1998, 36(10):
[75] 49-2173.

[76] Kolpin D W, Furlong E T, Meyer M T, et
[77] al. Pharmaceuticals, hormones, and other organic
[78] wastewater contaminants in US streams, 1999—2000:
[79] a national reconnaissance [J]. Environmental Science
[80] & Technology, 2002, 36(6): 1202-1211.

[81] Wu M, Wang L, Xu G, et al. Seasonal and spatial
[82] distribution of 4-tert-octylphenol, 4-nonylphenol and
[83] bisphenol A in the Huangpu River and its tributaries,
[84] Shanghai, China [J]. Environmental Monitoring and
[85] Assessment, 2013, 185: 3149-3161.

[86] Ike M, Jin C S, Fujita M. Biodegradation of
[87] bisphenol A in the aquatic environment [J]. Water
[88] Science and Technology, 2000, 42(7/8): 31-38.

[89] Klecka G M, Gonsior S J, West R J, et al.
[90] Biodegradation of bisphenol A in aquatic environments:
[91] river die-away [J]. Environmental Toxicology
[92] and Chemistry, 2001, 20(12): 2725-2735.

[93] Voordeckers J W, Fennell D E, Jones K, et al.
[94] Anaerobic biotransformation of tetrabromobisphenol
[95] A, tetrachlorobisphenol A, and bisphenol A in
[96] estuarine sediments [J]. Environmental Science &
[97] Technology, 2002, 36(4): 696-701.

[98] Belfroid A, Van Velzen M, Van Der H B, et
[99] al. Occurrence of bisphenol A in surface water and
[100] uptake in fish: evaluation of field measurements [J].
[101] Chemosphere, 2002, 49(1): 97-103.

[102] Lindholm C, Pedersen K L, Pedersen S N.
[103] Estrogenic response of bisphenol A in rainbow

[104] trout (Oncorhynchus mykiss) [J]. Aquatic Toxicology,
[105] 00, 48(2/3): 87-94.

[106] Honkanen J O, Holopainen I J, Kukkonen J
[107] V. Bisphenol A induces yolk-sac oedema and other
[108] adverse effects in landlocked salmon (*Salmo salar* m.
[109] sebago) yolk-sac fry [J]. Chemosphere, 2004, 55(2):
[110] 7-196.

[111] Ishihara K, Nakajima N. Improvement of marine
[112] environmental pollution using eco-system: decomposition
[113] and recovery of endocrine disrupting chemicals
[114] by marine phyto- and zooplanktons [J]. Journal of
[115] Molecular Catalysis B: Enzymatic, 2003, 23(2): 419-
[116] 424.

[117] Tabata A, Kashiwad A S, Ohnishi Y, et al. Estrogenic
[118] influences of estradiol-17 beta, p-nonylphenol
[119] and bisphenol-A on Japanese Medaka (*Oryzias*
[120] *latipes*) at detected environmental concentrations [J].
[121] Water Science and Technology, 2001, 43(2): 109-116.

[122] Van Den B K, Verheyen R, Witters H. Comparison
[123] of vitellogenin responses in zebrafish and
[124] rainbow trout following exposure to environmental
[125] estrogens [J]. Ecotoxicology and Environmental
[126] Safety, 2003, 56(2): 271-281.

[127] Brian J V, Harris C A, Scholze M, et al. Accurate
[128] prediction of the response of freshwater fish to
[129] a mixture of estrogenic chemicals [J]. Environmental
[130] Health Perspectives, 2005, 113(6): 721-728.

[131] Arukwe A, Celius T, Walther B T, et al. Effects
[132] of xenoestrogen treatment on zona radiata protein
[133] and vitellogenin expression in Atlantic salmon (*Salmo*
[134] *salar*) [J]. Aquatic Toxicology, 2000, 49(3): 159-170.

[135] Lee C, Na J G, Lee K C, et al. Choriogenin
[136] mRNA induction in male medaka, *Oryzias latipes* as
[137] a biomarker of endocrine disruption [J]. Aquatic Toxicology,
[138] 02, 61(3/4): 233-241.

[139] Nishizawa H, Morta M, Sugimoto M, et al.
[140] Effects of in utero exposure to bisphenol A on mRNA
[141] expression of arylhydrocarbon and retinoid receptors
[142] in murine embryos [J]. Journal of Reproduction and
[143] Development, 2005, 51(3): 315-324.

[144] 林浩然. 鱼类生理学[M]. 广州: 中山大学出版社, 2011:
[145] 0-306.

[146] Sohoni P, Tyler C R, Hurd K, et al. Reproductive
[147] effects of long-term exposure to bisphenol a in
[148] the fathead minnow (*Pimephales promelas*) [J]. Environmental
[149] Science & Technology, 2001, 35(14): 2917-
[150] 2925.

[151] Lee Y M, Seo J S, Kim I C, et al. Endocrine
[152] disrupting chemicals (bisphenol A, 4-nonylphenol, 4-
[153] tert-octylphenol) modulate expression of two distinct
[154] cytochrome P450 aromatase genes differently in
[155] gender types of the hermaphroditic fish *Rivulus*
[156] *marmoratus* [J]. *Biochemical Biophysical Research*
[157] *Communications*, 2006, 345(2): 894-903.
[158] Kishida M, McLellan M, Miranda J A, et al.
[159] Estrogen and xenoestrogens upregulate the brain
[160] aromatase isoform (P450aromB) and perturb markers
[161] of early development in zebrafish (*Danio rerio*)
[162] *Comparative Biochemistry and Physiology*
[163] *Part B: Biochemistry & Molecular Biology*, 2001,
[164] 9(2/3): 261-268.
[165] Kang I J, Yokota H, Oshima Y, et al. Effects of
[166] bisphenol A on the reproduction of Japanese medaka
[167] (*Oryzias latipes*) [J]. *Environmental Toxicology and*
[168] *Chemistry*, 2002, 21(11): 2394-2400.
[169] Haubruge E, Petit F, Gage M J. Reduced sperm
[170] counts in guppies (*Poecilia reticulata*) following
[171] exposure to low levels of tributyltin and bisphenol
[172] *Proceedings of the Royal Society B: Biological*
[173] *Sciences*, 2000, 267(1459): 2333-2337.
[174] Lahnsteiner F, Berger B, Kletzl M, et al. Effect
[175] of bisphenol A on maturation and quality of semen
[176] and eggs in the brown trout, *Salmo trutta f. fario* [J].
[177] *Aquatic Toxicology*, 2005, 75(3): 213-224.
[178] Hatef A, Alavi S M, Abdulfatah A, et al.
[179] Adverse effects of bisphenol A on reproductive physiology
[180] in male goldfish at environmentally relevant
[181] concentrations [J]. *Ecotoxicology and Environmental*
[182] *Safety*, 2012, 76(2): 56-62.
[183] Ramakrishnan S, Wayne N L. Impact of bisphenol
[184] A on early embryonic development and reproductive
[185] maturation [J]. *Reproductive Toxicology*, 2008, 25(2):
[186] 7-183.
[187] Chan W K, Chan K M. Disruption of the
[188] hypothalamic-pituitary-thyroid axis in zebrafish
[189] embryo-larvae following waterborne exposure to
[190] BDE-47, TBBPA and BPA [J]. *Aquatic Toxicology*,
[191] 12, 108: 106-111.
[192] Mandich A, Bottero S, Benfenati E, et al.
[193] In vivo exposure of carp to graded concentrations
[194] of bisphenol A [J]. *General and Comparative Endocrinology*,
[195] 07, 153(1/2/3): 15-24.
[196] Yokota H, Tsuruda Y, Maeda M, et al. Effect
[197] of bisphenol A on the early life stage in Japanese

[198] medaka (*Oryzias latipes*) [J]. *Environmental Toxicology*

[199] *and Chemistry*, 2000, 19(7): 1925-1930.

[200] Milla S, Depiereux S, Kestemont P. The effects

[201] of estrogenic and androgenic endocrine disruptors on

[202] the immune system of fish: a review [J]. *Ecotoxicology*,

[203] 11, 20(2): 305-319.

[204] Thilagam H, Gopalakrishnan S, Bo J, et al.

[205] Effect of 17 beta-estradiol on the immunocompetence

[206] of Japanese sea bass (*Lateolabrax japonicus*) [J].

[207] *Environmental Toxicology and Chemistry*, 2009,

[208] (8): 1722-1731.

[209] Harikrishnan T, Singaram G, Bo J, et al. The

[210] effect of 17b-estradiol on the immunocompetence

[211] of Japanese sea bass (*Lateolabrax japonicus*) [J].

[212] *Environmental Toxicology and Chemistry*, 2009,

[213] (8): 1722-1731.

[214] Yin D Q, Hu S Q, Gu Y, et al. Immunotoxicity of

[215] bisphenol A to *Carassius auratus* lymphocytes and

[216] macrophages following in vitro exposure [J]. *Journal*

[217] *of Environmental Sciences*, 2007, 19(2): 232-237.

[218] Watanuki H, Yamaguchi T, Sakai M. Suppression

[219] in function of phagocytic cells in common carp *Cyprinus*

[220] *carpio* L. injected with estradiol, progesterone

[221] or 11-ketotestosterone [J]. *Comparative Biochemistry*

[222] *and Physiology Part C: Toxicology and Pharmacology*,

[223] 02, 132(4): 407-413.

[224] Yamaguchi T, Watanuki H, Sakai M. Effects of

[225] estradiol, progesterone and testosterone on the function

[226] of carp, *Cyprinus carpio*, phagocytes in vitro [J].

[227] *Comparative Biochemistry and Physiology Part C:*

[228] *Toxicology and Pharmacology*, 2001, 129(1): 49-55.

[229] Jin Y, Chen R, Liu W, et al. Effect of endocrine

[230] disrupting chemicals on the transcription of genes

[231] related to the innate immune system in the early

[232] developmental stage of zebrafish (*Danio rerio*) [J].

[233] *Fish & Shellfish Immunology*, 2010, 28(5/6): 854-861.

[234] Moens L N, Van D V K, Van Remortel P, et

[235] al. Expression profiling of endocrine-disrupting compounds

[236] using a customized *Cyprinus carpio* cDNA

[237] microarray [J]. *Toxicological Sciences*, 2006, 93(2):

[238] 8-310.

[239] Wu M, Xu H, Shen Y, et al. Oxidative stress in

[240] zebrafish embryos induced by short-term exposure

[241] to bisphenol A, nonylphenol, and their mixture [J].

[242] *Environmental Toxicology and Chemistry*, 2011,

[243] (10): 2335-2341.

[244] Xu H, Yang M, Qiu W, et al. The impact of

[245] endocrine-disrupting chemicals on oxidative stress
[246] and innate immune response in zebrafish embryos
[247] *Environmental Toxicology and Chemistry*, 2013,
[248] (8): 1793-1799.

[249] Rubtsov A V, Rubtsova K, Kappler J W, et
[250] al. Genetic and hormonal factors in female-biased
[251] autoimmunity [J]. *Autoimmunity Reviews*, 2010,
[252] 7): 494-498.

[253] Miao S, Gao Z, Kou Z, et al. Influence of bisphenol
[254] a on developing rat estrogen receptors and some
[255] cytokines in rats: a two-generational study [J]. *Journal*
[256] *of Toxicology and Environmental Health A*, 2008,
[257] (15): 1000-1008.

[258] Bonefeld-Jorgensen E C, Long M, Hofmeister
[259] M V, et al. Endocrine-disrupting potential of bisphenol
[260] A, bisphenol A dimethacrylate, 4-n-nonylphenol,
[261] and 4-n-octylphenol in vitro: new data and a brief
[262] review [J]. *Environmental Health Perspectives*, 2007,
[263] 5(S1): 69-76.

[264] Tsigos C, Chrousos G P. Hypothalamic-pituitary-adrenal
[265] axis, neuroendocrine factors and stress [J].
[266] *Journal of Psychosomatic Research*, 2002, 53(4): 865-
[267] 871.

[268] Sathyanarayana S, Braun J M, Yolton K, et
[269] al. Case report: high prenatal bisphenol a exposure
[270] and infant neonatal neurobehavior [J]. *Environmental*
[271] *Health Perspectives*, 2011, 119(8): 1170-1175.

[272] Suzuki T, Mizuo K, Nakazawa H, et al. Prenatal
[273] and neonatal exposure to bisphenol-A enhances
[274] the central dopamine D1 receptor-mediated action in
[275] mice: enhancement of the methamphetamine-induced
[276] abuse state [J]. *Neuroscience*, 2003, 117(3): 639-644.

[277] Mizuo K, Narita M, Yoshida T, et al. Functional
[278] changes in dopamine D3 receptors by prenatal
[279] and neonatal exposure to an endocrine disruptor
[280] bisphenol-A in mice [J]. *Addiction Biology*,
[281] 04, 9(1): 19-25.

[282] Iwakura T, Iwafuchi M, Muraoka D, et al. In
[283] vitro effects of bisphenol A on developing hypothalamic
[284] neurons [J]. *Toxicology*, 2010, 272(1/2/3): 52-58.

[285] Lee Y M, Seong M J, Lee J W, et al. Estrogen
[286] receptor independent neurotoxic mechanism of
[287] bisphenol A, an environmental estrogen [J]. *Journal*
[288] *of Veterinary Science*, 2007, 8(1): 27-38.

[289] Veerann A, Shetty K T, Takahashi M, et al.
[290] Cdk5 and MAPK are associated with complexes of

[291] cytoskeletal proteins in rat brain [J]. Molecular Brain
[292] Research, 2000, 76(2): 229-236.
[293] Negishi T, Ishii Y, Kyuwa S, et al. Inhibition of
[294] staurosporine-induced neuronal cell death by bisphenol
[295] A and nonylphenol in primary cultured rat hippocampal
[296] and cortical neurons [J]. Neuroscience Letters,
[297] 03, 353(2): 99-102.
[298] Vom S F S, Hughes C. An extensive new literature
[299] concerning low-dose effects of bisphenol A shows the
[300] need for a new risk assessment [J]. Environmental
[301] Health Perspectives, 2005, 113(8): 926-933.
[302] Wolstenholme J T, Rissman E F, Connelly
[303] J J. The role of bisphenol A in shaping the brain,
[304] epigenome and behavior [J].Hormones and Behavior,
[305] 11, 59(3): 296-305.

[1] 吴明红, 潘辰苑, 杨明, 钱冬英. 鱼体胆汁中壬基酚和双酚A的分析方法[J]. 上海大学学报(自然科学版), 2013,19(4): 423-428
[2] 刘志睿 吉永华. 抗毒血清科技创新崎岖路上的簇星点点[J]. 上海大学学报(自然科学版), 2012,34(5): 299-303