Exposure of Aquatic Receptors to Bisphenol A: Evidence that Current Risk Models may not be Sufficiently Protective

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Background

Bisphenol A [BPA; 2,2-bis(4-hydroxyphenyl)propane],a xenoestrogen identified as an agonist of the estrogen receptor, is an industrially important chemical that is used as a primary raw material for the production of engineering plastics (*e.g.*, polycarbonate/epoxy resins), food cans (*i.e.*, lacquer coatings), and dental composites/sealants. Despite its biodegradability and short half life, BPA has been implicated in various human and wildlife health endpoints such as infertility, impaired reproduction, precocious puberty, endometriosis and production of breast, vaginal, prostate, and uterine cancer. BPA, a known endocrine disruptor has been identified in surface waters and, hence has been the subject of considerable research into its potential effects on aquatic organisms.

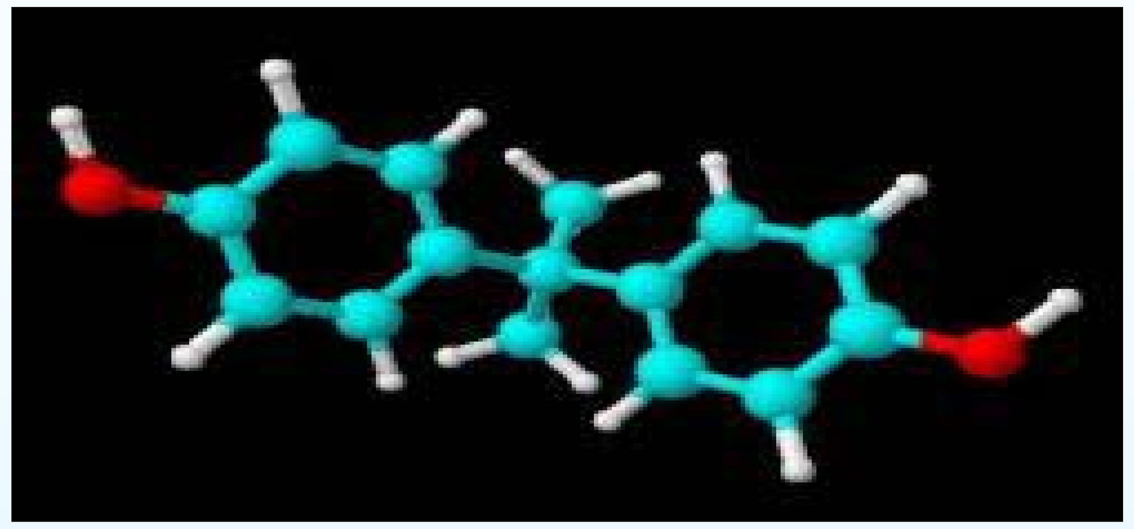


Figure 1. Molecular Structure of BPA

Aims and Objectives

The overall aim of this research was to conduct and update an aquatic hazard assessment of BPA using a weight of evidence approach. To accomplish this task the following three main objectives were utilized;

1) Determine best available aquatic sensitivity data for BPA through literature search.
2) Conduct and update an aquatic hazard assessment for BPA using a weight-of-evidence approach, using the ecologically relevant endpoints of survival, growth and development, and reproductive success.
3) Determine protectiveness of the aquatic receptors from possible adverse effects of BPA, using a nonparametric hazardous concentration for 5% of the species (HC_5) approach which, protects 95% of the population.

Method

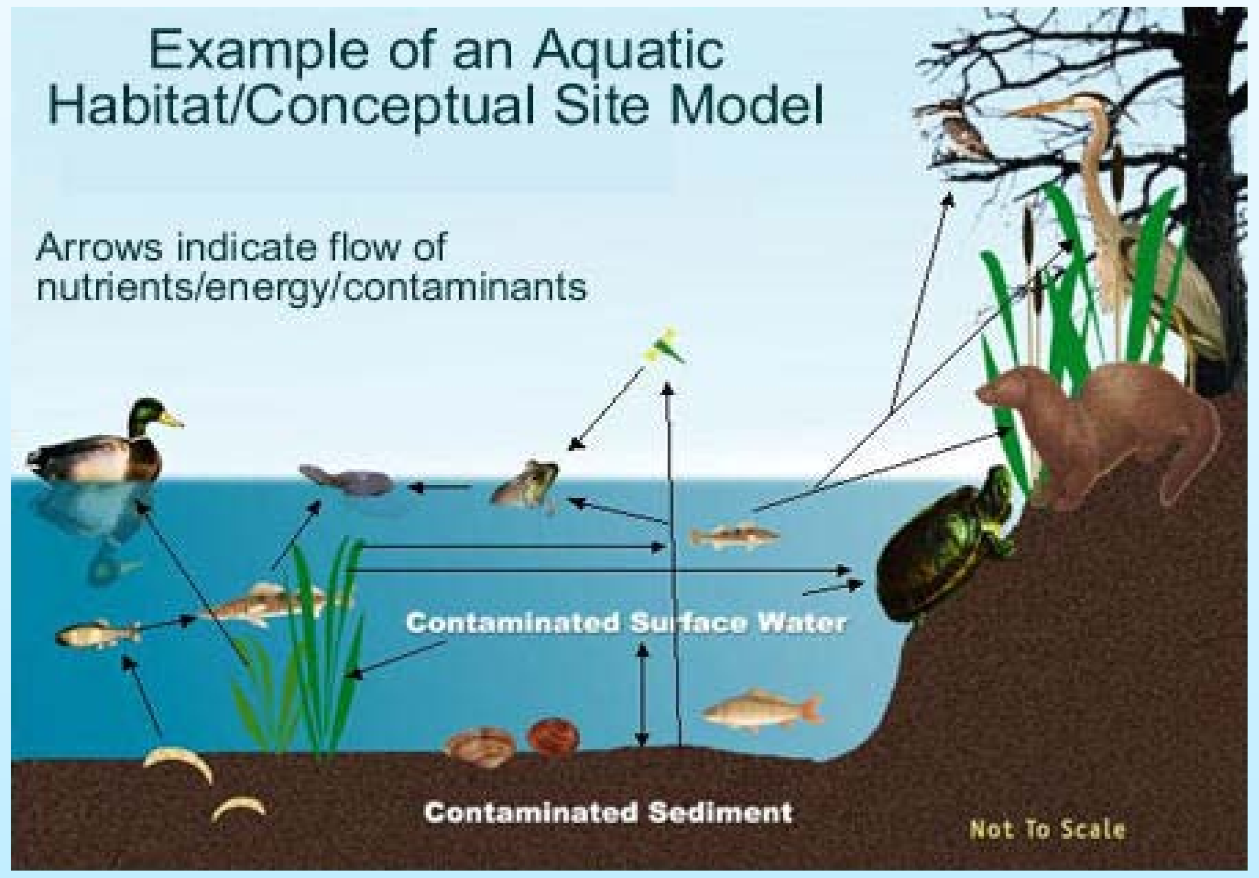
A critical review of the available literature on BPA aquatic toxicity studies through 2008 was performed based on a set of established criteria and results tabulated.

Conduct and update an aquatic hazard assessment for BPA using a weight-of-evidence approach, using the ecologically relevant endpoints of survival, growth and development, and reproductive success.

Order the BPA sensitivity data NOEC and LOEC concentrations were listed in a from high to low sensitivity (smallest to largest concentration) This was done to determine the lowest concentration (NOEC) at which there was no reported toxic effect or the lowest concentration (LOEC) at which there was a toxic effect.

Compare the BPA concentration range of derived hazard assessment in objective two to the published BPA concentration range found in the aquatic environment, to determine if the aquatic system is sufficiently protected from possible adverse effects of BPA.

Next, using NOEC values only a PNEC for BPA was calculated using the HC_5 approach, using van der Hoeven's nonparametric HC_5 estimation .



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Results

Sixty one (61) studies which represented twenty four (24) different species were reviewed and included in this analysis. A total of ninety three (93) LOEC and NOEC values were obtained from the studies deemed acceptable and included in the analysis. BPA sensitivities ranged from 0.002µg/L (growth NOEC) to 12500µg/L (reproduction LOEC), Figure 2. A cluster of BPA sensitivities (NOEC and LOEC) was observed from 0.0483µg/L to 12500µg/L Figure 3 & 4. Individually, BPA sensitivities for the endpoint survival clustered between 2.4ug/L and 3120ug/L, while sensitivities for the endpoint growth and development clustered from 0.002ug/L to 1820µg/L and sensitivities for the endpoint reproduction clustered between 0.0079 µg/L and 2280µg/L.

The PNEC for BPA was 0.01µg/L. The sensitivity for the probability of underestimating HC5 is only 5%, that is, HC5 (0.05) was found to be 0.002µg/L. The conservative 95% confidence interval was found to be (0,8)µg/L.

The reported concentration of BPA found in the aquatic environment is 8µg/L or less.

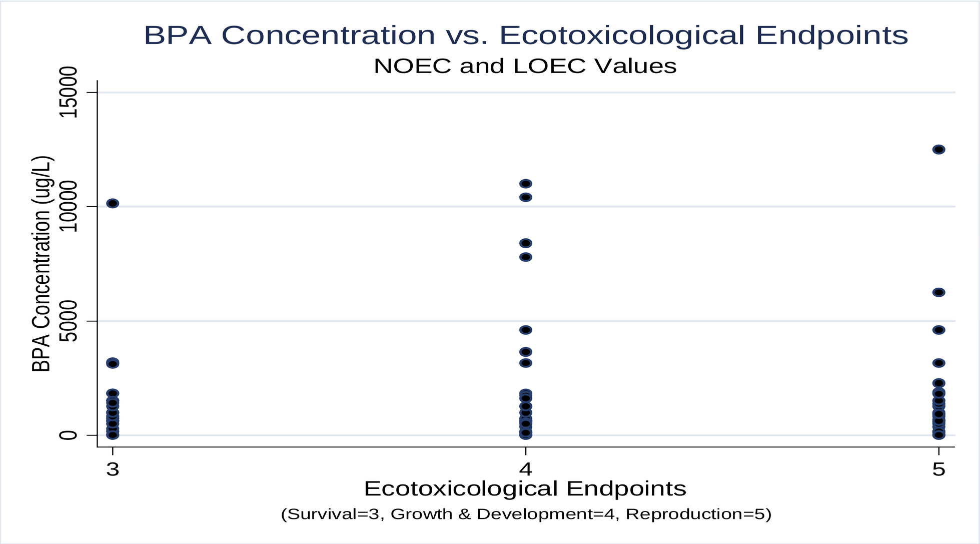

Figure 2. BPA Concentrations vs. Ecotoxicological Endpoints

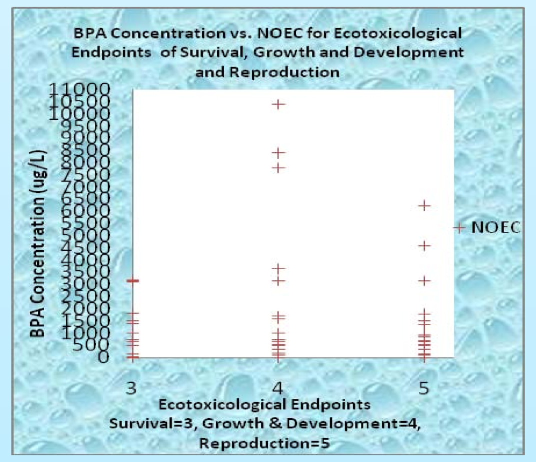

Figure 3. Clustered BPA NOEC values

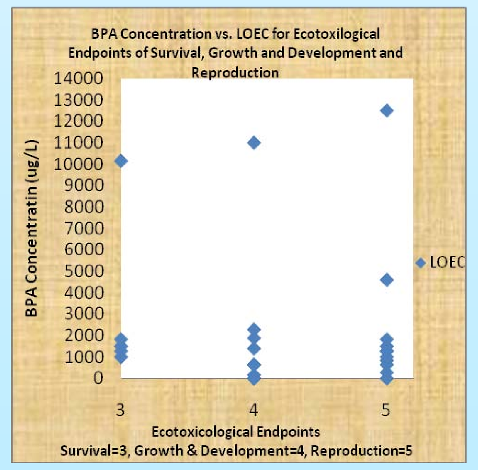

Figure 4. Clustered BPA LOEC Values

Conclusions

1. The results of this research suggest that the aquatic environment is not sufficiently protected from adverse effects of BPA at the established concentration of 8µg/L or less.
2. Aquatic receptors previously thought to be safe may be at risk for adverse effects of BPA.
3. More research is needed to understand the full effects of BPA in the aquatic environment.
4. Additional research should focus on both laboratory and field tests for better correlation of results.
5. Different approaches other than the weight of evidence should be explored for completing a hazard assessment of BPA.
6. There needs to be testing and management and regulation of BPA and other xenoestrogens in WWTP effluents. Standardized testing methods should be established as different testing methods that are available avail themselves to different and varied results

Public Health Implications

1. Species in the wild are sentinels for human exposure ("the canary in the mine"). Sentinel animals may provide early warning of potential risks before disease develops in human populations.
2. Potential applications for sentinel species includes monitoring environmental media, identifying new exposures of potential concern as a result of observing changes in wild animal populations, and supporting risk assessment at several points in the process.
3. Some species are a part of the human food chain and thus another route of exposure for humans to BPA.
4. Understanding the species and concentrations of BPA in the aquatic environment is imperative for environmental public health tracking of associated disease states, and in the regulation of fish or wildlife consumption from rivers and lakes.
5. Having an updated BPA aquatic hazard assessment will help to determine risks for both humans and wildlife populations from environmentally relevant concentrations of BPA. Further, it will foster the development of new policies and regulations regarding the production and proper management of BPA in the aquatic environment.