BIOACCUMULATIVE CONTAMINANTS IN FISH, RISK ASSESSMENT & FISH COMSUMPTION ADVISORIES

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ABSTRACT

Some issues surrounding management of chemical contaminants which bioaccumulate in fish are reviewed. Contaminants in aquatic life are of increasing concern for fishery management, environmental and public health agencies as well as for recreational and subsistence anglers. The complexities in the development of human health fish consumption advisories result from lack of standard sampling and analytical methods, numerous risk assessment models, changing risk management policies, ineffective risk communication and opposing resource management goals. A 1989 survey of the states found that Georgia is one of ten states which does not base fish consumption advisories on a risk assessment approach. The current status of fish advisory development among federal, state and local agencies is further complicated by a fragmented regulatory authority.

INTRODUCTION

The USEPA, with the states, share responsibilities under various regulatory authorities to advise sport and subsistence anglers on contaminants in fish. Amendments to the 1987 Clean Water Act required the states, with EPA concurrence, to set numeric standards for toxic compounds where only narrative (i.e., "no toxics in toxic amounts") standards had been required previously. This focused attention on the problem, and EPA applied the risk assessment methodology for human health, consistent with water quality criteria published in the Federal Register (1980). The risk assessment methodology includes hazard assessment, dose response assessment, exposure assessment and risk characterization along with an uncertainty analysis.

Hazard assessment is the qualitative evaluation of the potential for a substance to cause adverse health effects (e.g., birth defects, cancer) in animals or humans. Dose response assessment is the quantitative estimation of the relationship between the dose of a substance and the probability of an adverse health effect. Exposure assessment is the characterization of the populations exposed to the toxic chemicals of concern; the environmental fate and transport pathways; and the magnitude, frequency and duration of exposure. Risk characterization is the integration of qualitative and quantitative information from the first three steps, leading to an estimate of risk for the health effects of concern.

There have been cases over the last several years where public warnings from local, state and federal regulatory agencies regarding the consumption of sport fish have been inconsistent. This has been particularly evident on waters shared by two or more states. Notable examples in Georgia include Lake Hartwell and the Coosa River. The Great Lakes States (Great Lakes Fish Consumption Advisory Task Force) and those bordering the Mississippi (Mid-America Fish Contaminants Group) and Ohio Rivers (Ohio River Sanitation Commission) have endeavored to provide consistent advisory information but a standard advisory protocol has yet to be agreed upon.

In most instances a clear statement of purpose has not been developed as a first step. Most fish sampling for contaminants and resultant advisories have been reactive instead of proactive. Programs are needed which have continuity through the years. One such sport-fish contaminant monitoring program has been operated by the Ontario Ministry of the Environment (1990) over the last 20 years. This program is a model for testing, consumption advisories and public communication which enjoys acceptance among anglers. It also plays a key role in the detection and control of water pollution.

Sampling

Several guidelines for sampling fish have been developed, but a comprehensive sampling protocol for contaminants is needed for both organics and trace metals. It is imperative that adjoining jurisdictions employ the same strategy to develop comparable data for purposes of exchange. Ecological and environmental monitoring

considerations require whole fish analysis while human health is based on filet samples. There is general agreement that filets provide the basis for advisories, but there is considerable variability in what constitutes the best filet (e.g., area to be fileted, skin on or off, belly flap included or excluded). The use of composite samples instead of individual fish is usually conceded as a cost saving measure but has the drawback of reducing the statistical rigor of the data. The species selected, size, trophic level (bottom feeders or predators), sample preparation and handling are some of the issues to be addressed.

Chemical Analysis

The analytical methodology for each analyte of concern needs precise specification so that the data can be shared between jurisdictions. The required detection levels for each analyte must be specified to ensure that the resulting data will be useful. Joint development of laboratory protocols and procedures along with stringent quality assurance and quality control (QA/QC) mechanisms should be conducted between jurisdictions using round robin evaluations. To provide reliable data, split samples should be a normal routine for QA/QC among analytical laboratories involved in fish monitoring programs. The development of a laboratory methodology for chlordane by the Mid-America Fish Contaminants Group is a good example of such efforts.

The bioaccumulative analytes of concern typically include the organochlorine pesticides, PCBs, dioxins/dibenzofurans, PAHs, other chlorinated organics and some trace metals (Cunningham, et. al, 1990). New information is indicating that additional analytes will be added in the future. Congener (closely related compounds with the same basic structure but different number of substitutions, e.g., chlorine) specific analyses are becoming the rule to quantitate dioxin/furans, PCBs, and chlordane (USEPA, 1990a) which require more specialized instrumentation and training and are therefore more costly. These data are needed to improve the toxicological dose response assessment used in risk characterization.

A common database should be created and developed to allow the data to be shared between jurisdictions at least for shared waterbodies. Such a database would incorporate information from a wide variety of sources, following appropriate QA/QC and would eventually provide a powerful, historical information base with which to conduct trend analysis. If trend analyses were possible now they would be very helpful in placing contaminant issues in perspective. The sharing of data which is costly to develop would help to maximize the resources expended by each jurisdiction.

Exposure Assessment

The local consumption patterns for sport and subsistence anglers are essential for the accurate determination of exposure. A wide range of consumption values have been used or suggested ranging from 6.5 g/day to 165 g/day for heavy fish eaters. The situation is complicated by how to assess the consumption patterns of infrequent, average or avid anglers as well as those utilizing different waterbodies or consuming different species. The effects of cooking on residue levels in tissue could be considered in consumption advisories if more were known about various cooking methods. The USEPA does not include the effects of cooking in its risk assessment procedure. In addition, the pharmacokinetics of contaminants when ingested needs further development because the current assumption of 100% absorption in the gut may be an overestimate.

The health endpoint presumed most often is the cancer risk associated with the majority of organic contaminants. It is becoming more evident that advisories based solely on carcinogenicity may not provide sufficient evaluation. Alternate endpoints which are becoming more important and should be considered in addition to cancer are reproductive and developmental effects.

Advisory Development

The manner in which advisories are derived has long been a source of contention among various jurisdictions and public interest groups. Advisory development is the stage where the risk assessment including an uncertainty analysis is modified by risk management considerations including economics, politics, law and social interactions. The risk management decision is designed to achieve control of the exposure. The methodologies which have been applied or proposed for use in advisory development are: 1) FDA action levels (Bolger, et. al, 1990, 2) USEPA quantitative risk assessment (USEPA, 1989, 1990b), 3) weight of evidence approach (Sielken, 1987), 4) market basket approach, and 5) safety factor approach.

FDA Action Levels were used by EPA and the states until 1987 to determine the extent of concern for a limited number of chemical contaminants in fish tissue. FDA action levels have been the basis of many advisory systems and continue to be used by the State of Georgia which currently has five advisories in effect. The wide acceptance has been based on the credibility of the source, the long historical use, and the linkage of sport fish advisories to commercial fish safety. Their use has, however, been called into question because a complete risk assessment derivation has been unclear until recently, risk management considerations are included and the action levels have not been re-evaluated for a considerable period of time. Many states have requested a common risk assessment approach between FDA and EPA, but the

agencies have different regulatory responsibilities. FDA is responsible for assuring the safety of the interstate food supply and for enforcing food tolerances under the Food, Drug and Cosmetics Act. EPA is responsible for maintaining "fishable, swimmable" waters throughout the country under the Clean Water Act. The latter includes risk assessment advice to States on contaminated fish consumed by sport and subsistence anglers.

Quantitative Risk Assessment was developed by USEPA for use in the assessment of consumer cancer risks from contaminants in fish. It has the strength of wide acceptance and use in regulatory settings and a large amount of scientific effort behind it. The increased life-time (70 years) risk is estimated using cancer potency factors for toxic substances in a linearized multi-stage model with no threshold. EPA assumes that rats, mice and humans are at equal risk at the same exposure measured in milligrams of carcinogen per square meter of body surface per day and that at low environmental levels, the relation between dose and exposure is linear. The upper 95% confidence limit is presented as the worst case and is likely to over-estimate the true risk. Because its use is mandated by law and regulation, it may lag the rapid changes occurring in the evolution of this science even though the agency is attempting to avoid this situation. The risk assessment is population based and does not render individual health advice.

Weight of Evidence Approach is an emerging methodology which utilizes the precepts of quantitative risk assessment. By utilizing the totality of available data in terms of toxicity studies, dose-response models, exposure assessments, etc., this approach provides a distribution of risk probabilities which allows the risk assessor and manager to view the entire risk range as well as the areas with highest probability for containing the true risk. Full disclosure of the risk range may provide the basis for acceptance of a risk management strategy by the States which can be communicated to the public.

The Market Basket Approach attempts to link the risk of sport fish consumption to that of store-bought fish under the assumption that the risk associated with store-bought fish is an "acceptable risk". There appears to be little merit in this approach for most of the country which has small commercial fisheries limited to many small waterbodies with highly variable contaminant loadings. The effort required to develop knowledge of the market basket would double the analytical costs and minimize the resources available to identify and monitor contaminant burdens in the numerous local sport fish populations across the country which never enter the market.

The Safety Factor Approach is derived from classical regulatory toxicology and is predicated on a threshold effect for adverse outcomes. It utilizes the existence of a No-Observed-Adverse-Effect-Level (NOAEL) or Lowest-Observed-Adverse-Effect-Level (LOAEF) and appropriate safety factors to identify an exposure level that should be considered to pose no danger. Europe and Canada take this approach for carcinogen regulations. If non-cancer endpoints (reproductive hazard and neurotoxicity) are considered as the most realistic problems posed by consumption of contaminated fish, this approach may be appropriate.

Risk Management/Communication

A major problem in managing environmental resources and protecting public health is the inter-relationship among risk assessment, risk management and risk communication. Toxicological risk assessment has been and remains regulatory driven. This has two implications: 1) risk management considerations are inseparable from risk assessment choices; and 2) risk communication is critically important since public pressure has significant effects on the regulatory process. These relationships must be better understood for all parties to coordinate and communicate federal/state efforts more effectively to the public.

Traditionally fisheries managers have worked largely alone, attempting to produce the greatest amount of fish or recreation from each lake or stream. Economists, health officials, and others less directly impacted, enter the decision making process only after problems posed by toxic contaminants and competing user groups arise. Fisheries managers must improve their knowledge of the transport of toxic contaminants through the aquatic environment and learn to assess all risks--social, economic and public health--from various management alternatives. Fisheries managers must involve interdisciplinary teams composed of health professionals, economists, social scientists and other affected people in development of new management programs.

Conclusions

Contaminants in fish will continue to pose public health concerns into the future and an improved risk assessment will be the means for developing advisories. Every state including Georgia should become an active participant in the development and application of risk assessment methodology. It is clear that a common national fish consumption advisory protocol is needed which will allow modification as scientific knowledge advances. The management of environmental contaminant problems is extremely expensive and costs could be streamlined through a common protocol which would allow data sharing and uniform interpretation among adjoining jurisdictions. A national fish advisory protocol would facilitate continued management and use of the fishery resource while pollution control programs become more effective in prevention and removal of bioaccumulative toxic contaminants from the environment.

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