UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 1 8 1985

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Richard C. DeYoung, Director
Office of Inspection and Enforcement

FROM: Robert B. Minogue, Director
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER # 141 - BIOACCUMULATION OF PHOSPHORUS-32 IN BLUEGILL AND CATFISH

Introduction:

This memorandum transmits the results of a completed research project on determining the bioaccumulation factor for phosphorus-32 in edible fish tissues. The project was initiated in response to a request from the Office of Inspection and Enforcement, RR-IE-77-1, which needed this information in order to decide whether liquid effluents from power plants should be analyzed for P-32 concentration. The work was performed by the Environmental Resources Center of the Georgia Institute of Technology with Dr. Bernd Kahn as the principal investigator under the direction of the Health Effects Branch of the Office of Nuclear Regulatory Research (RES). The final report entitled, "Bioaccumulation of P-32 in Bluegill and Catfish," NUREG/CR-3981, has been transmitted to your staff.

RIL #104 transmitted the results of a review of the relevant literature and described a suggested model for assessing phosphorus bioaccumulation and turnover in fish resulting from such discharges (NUREG/CR-1336). Because of the uptake and metabolism of phosphorus in fish, this pathway is important for estimating potential doses for compliance with 10 CFR 50, Appendix I. Your office (RR-NRR-80-6) requested experimental confirmation of the model proposed in NUREG/CR-1336.

In addition, considerable media attention was given to this pathway in 1981 when the Tennessee Valley Authority's Sequoyah Nuclear Plant discharged into Chicamauga Lake amounts of P-32 in excess of that allowed by the plant's technical specifications. The calculated dose to the bone marrow from ingestion of P-32 in fish was found to exceed the design objective of 10

mrem/yr for any organ. Questions as to whether the available effluent treatment systems were satisfactory and whether additional controls were required for limiting P-32 liquid discharges into the environment were raised.

Methodology

The P-32 accumulation and depuration (biological elimination) experiments were performed in two large flow-through tanks using Atlanta tap water which was determined to be representative of the freshwater environment into which P-32 was discharged. Local species of bluegill and catfish were fed a constant amount of P-32 spiked food per average body weight at one of two levels to determine the influence of high or low intake on bioaccumulation. Fish were sacrificed, dissected, and analyzed for P-32 and stable phosphorus at predetermined times. Bluegill were subjected to P-32 accumulation for 51 days and to depuration for the following 28 days. The catfish experiment had to be terminated after accumulation for 11 days due to accidental cutoff of the water supply.

Supporting experiments were performed to examine the influence of species (bluegill vs catfish), food (worms vs pellets), and water temperature. An additional experiment was conducted to determine the extent of P-32 uptake directly from water.

Results and Discussion

The elemental bioaccumulation factor, BF, is defined as:

$$BF = \frac{C_t}{C_w}$$

where in this study C is the concentration of phosphorus in mg/g and the subscripts t and w refer to moist edible tissue and water, respectively.

The radioisotope bioaccumulation factor, BF_r, can be defined analogously as:

$$BF_r = \frac{C_t^*}{C_w^*}$$

where the asterisks denote radioactivity levels in consistent units, such as disintegrations per minute per gram.

If the specific activity (P-32 activity per unit mass of phosphorus, a, is expressed as dpm/mg:

$$\frac{BF_r}{BF} = \frac{a_t}{a_w}$$

The values of BF reported and utilized for predicting radionuclide transfer are defined as equilibrium or steady-state values (i.e., the rate of intake equals the rate of elimination so that the amount retained is constant). For P-32 the equilibrium value of BF_r would apply to fish exposed to a constant P-32 specific activity in water for a sufficiently long time so that the specific activity in muscle (the edible tissue of concern) has reached a constant value. Under natural conditions the main source of phosphorus in fish is food, not water. Hence, the BF describes the indirect transfer of P-32 from water through biota at lower trophic (food chain or web) levels. If bioaccumulation of phosphorus throughout the food web is very rapid relative to the P-32 radioactive decay constant of 0.0485 d^{-1}, then the ratio BF_r/BF is essentially one to the point of food intake by the fish. Under these circumstances, the ratio can be expressed as:

$$\frac{BF_r}{BF} = \frac{a_t}{a_f}$$

where a_f is the specific activity in the food.

A phosphorus biological turnover constant of 0.0043d^{-1}, corresponding to a bioaccumulation factor ratio of P-32 relative to phosphorus of 0.081, was obtained for bluegill muscle. Combined with the generic (stable) phosphorus bioaccumulation factor of 70,000 determined in NUREG/CR-1336, this ratio yields a P-32 bioaccumulation factor of 6000. At the lower feeding rate the ratio was 0.064 giving BF_r=4000; an average BF_r of 5000 will be used. The BF_r values for catfish were approximately twice as high, but due to water supply failure depuration was not followed.

The aquarium experiments suggest that the higher factors are due to a much higher phosphorus intake, higher water temperature and higher retention from pellets than from worms.

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The results of each experiment are given in the tables and figures of NUREG/CR-3981, which has been provided to your staff. The most significant findings are the following:

1. Turnover constants and bioaccumulation factor ratios were similar in the skeleton, head, tail, and scales, all of them being approximately an order of magnitude below the values for muscle; gills had higher values than muscle, and viscera values were highest.

2. Fish fed larger amounts of food had higher P-32 turnover constants and bioaccumulation factor ratios in all tissues. The ratio of high-intake to low-intake biological turnover constants averaged 1.30 and showed no significant tissue dependent variation.

3. Some very high specific activity ratios during the first two weeks of accumulation, particularly in the viscera, do not fit the curve for the single-compartment model developed in NUREG/CR-1336.

4. The single compartment model provides a reasonable fit for the tissues that turn over more slowly, but depuration measurements show this model to be inappropriate for gills and viscera.

Conclusions and Recommendations

The results from the numerous experiments done for this study show conclusively that the value of 100,000 used in Regulatory Guide 1.109 for the phosphorus bioaccumulation factor for freshwater fish is at least an order of magnitude too high (100,000/5000=20).

For a typical nuclear power plant release of P-32 use of a 20-fold lower bioaccumulation factor results in a calculated dose which does not exceed the design objective for Appendix I of 10 CFR 50. In addition, measuring P-32 concentration is difficult because it emits no gamma radiation and therefore requires chemical separation and beta analysis. The relatively short half-life of P-32 necessitates fast analyses and precludes composite sampling. Because of these factors, P-32 analyses are expensive. Based on the results of this study, we find no need for reactor licensees to measure P-32 in effluents to assure compliance with Appendix I of 10 CFR 50 for the phosphorus in fish pathway. We understand that, based on the results from this study, NRR has changed the effluent monitoring requirements for P-32. We will revise Regulatory Guide 1.109 to incorporate the new bioaccumulation factor.

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For further information on this study, please contact Dr. Judith D. Foulke (427-4563).

Robert B Minogue

Robert B. Minogue, Director
Office of Nuclear Regulatory Research

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Original signed by:
ROBERT B. MINOGUE

Robert B. Minogue, Director
Office of Nuclear Regulatory Research

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RIL 141

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R 2813.04
RIL # 141
RR - NRR - 80-6
RR - IE - 77-1
NUREG/CR - 3981
NUREG/CR - 1336
NRC PDR

June 5, 1985

Return to RES
113055

MEMORANDUM FOR: Alois J. Burda, Chief
Program Planning and Control Branch
Policy Planning and Control Staff
Office of Nuclear Regulatory Research

FROM: Zoltan R. Rosztoczy, Chief
Research and Standards Coordination Branch
Division of Safety Technology
Office of Nuclear Reactor Regulation

SUBJECT: RESEARCH RESULTS UTILIZATION FORM

We have received Research Information Letter #141: Bioaccumulation of P-32 in Bluegill and Catfish. Enclosed is a completed Research Results Utilization Form, which provides the official NRR comments on the value of the research to the regulatory process.

Zoltan R. Rosztoczy, Chief
Research and Standards Coordination Branch
Division of Safety Technology
Office of Nuclear Reactor Regulation

Enclosure:
As Stated

cc: H. Denton
R. Bernero
W. Russell
H. Thompson
J. Knight
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K. Goller

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OFFICIAL PROGRAM OFFICE COMMENTS ON UTILIZATION OR VALUE OF RIL TO THE REGULATORY PROCESS
(Research Results Utilization Form)

RIL #: 141 Date Issued: 5/1/85 RRG: RRG Chair:

RIL Title: BIOACCUMULATION OF P-32 IN BLUE GILL AND CATFISH

Program Office: NRR Contact Name: Tin Mo Date: 5/21/85

Application to Regulatory Process:

The purpose of this research was to determine the bioaccumulation factor for phosphorus-32 in edible fish tissues. The project was initiated in response to a request from the Office of Inspection and Enforcement, RR-IE-77-1, which needed this information in order to decide whether liquid effluents from power plants should be analyzed for P-32. A final report, NUREG/CR-3981, with the same title as RIL #141 has been published.

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Impact of Results:

The results from the experiments done for this study confirm the model proposed in NUREG/CR-1336 and show that the value of 100,000 used in Regulatory Guide 1.109 for the phosphorus bioaccumulation factor for freshwater fish may be lowered.

The results from these studies have been very useful to NRR in reducing some of the surveillance requirements of nuclear power plants while still protecting the public's health and safety.

Comments/Remarks:

The research program is complete. No further work is scheduled nor recommended. The research results do not contain information that should be considered for Board notification.

RIL-141
R2813.04
RIL 141
RR-NRR-80-6
RR-IE-77-1
NUREG/CR-3981
NUREG/CR-1336
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