OCCUPATIONAL DOSE ASSESSMENT OF IODINE-131 AT AUSTRALIAN NUCLEAR SCIENCE &TECHNOLOGY ORGANISATION

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INTRODUCTION:

- ANSTO Internal Dosimetry provides monitoring and assessment of contaminant intake and their relevant doses.
- Direct measurements cover: organs, lungs or whole body.
- The detection systems are NaI, HPGe and Phoswich.
- Calibration phantoms are BOMAB and IAEA Thyroid.
- ICRP and IAEA publications are utilised to obtain the intake and the corresponding committed doses.

OBJECTIVES:

- To evaluate the thyroid's retention functions (RF) and data of Predicted Intake Fractions (PIF), given in ICRP publications 54&78, and their impact on earlier measurements.
- To Compare Iodine-131 Intakes of subjects, which obtained by the retention functions and data of Predicted Intake Fraction.
- To illustrate a realistic and practical "transfer time" that improve the accuracy of Intake.

THREE COMPARTMENTAL MODEL, ICRP-78 :

- Assumes three compartments for translocation.
- Provides Rate Constants between compartments.
- Provides data of predicted intake fraction (PIF).
- Transfer & Body compartments have different "OUT" Rate Constants.
- The following Retention Function was derived:

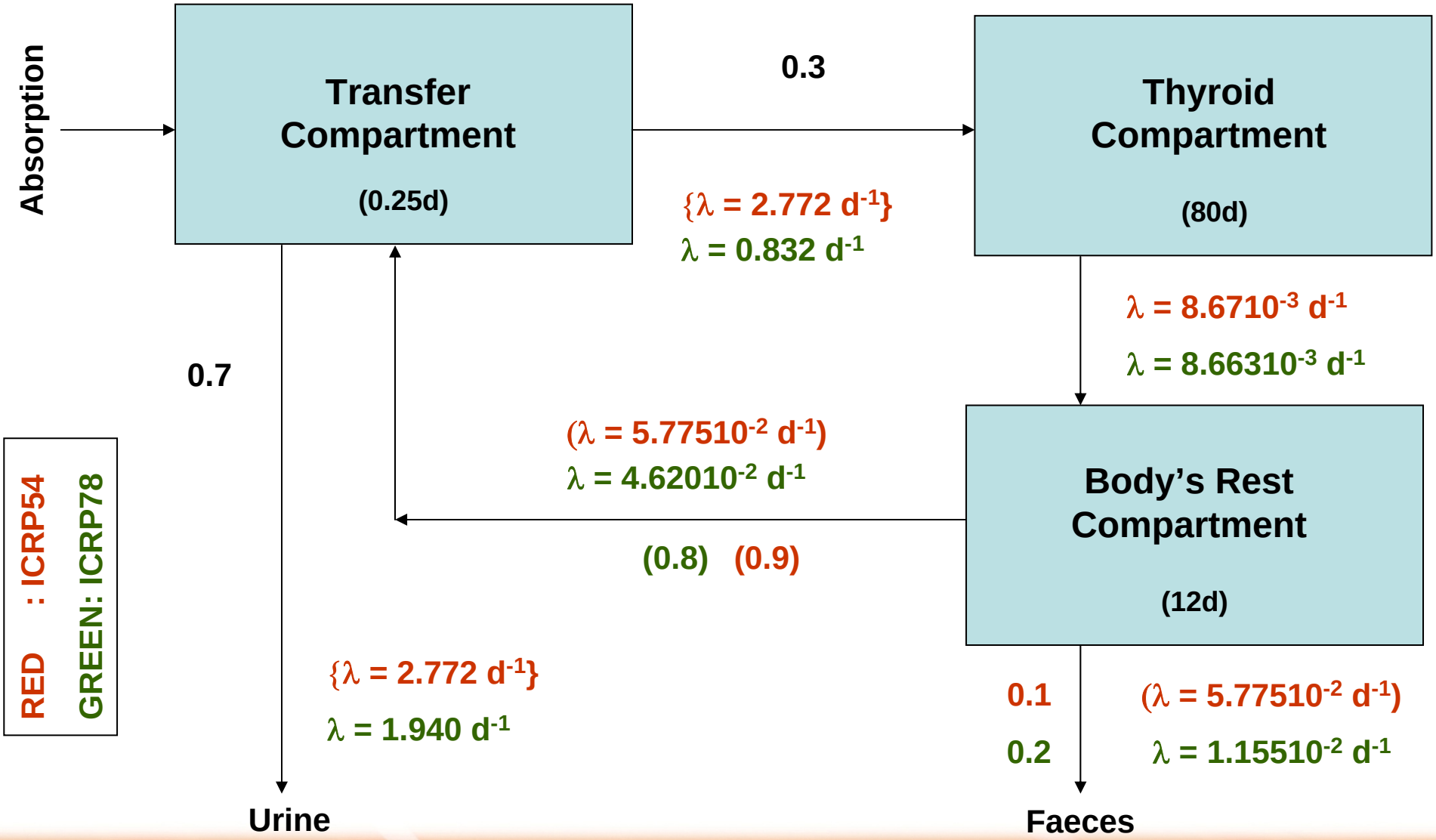
$$^{78}R_{Th,B} = -0.382\ e^{(-\ 0.832\ t)} + 0.24\ e^{(-\ 8.663 \times 10\text{-}3\ t)} + 0.072\ e^{(-\ 4.62 \times 10\text{-}2\ t)}$$

THREE COMPARTMENTAL MODEL, ICRP-54:

- Assumes three compartments for translocation.
- Provides Rate Constants between compartments.
- Provides data of predicted intake fraction (PIF).
- Transfer & Body compartments have same “OUT” Rate Constants.
- Provides Retention Function:

$$^{54}R_{Th,B} = -0.33\, e^{(-\,2.888\ t)} + 0.31\, e^{(-\,5.775\times10^{-3}\ t)} + 0.018\, e^{(-\,6.3\times10^{-2}\ t)}$$

THREE COMPARTMENTAL BIOKINETIC MODEL OF THYROID



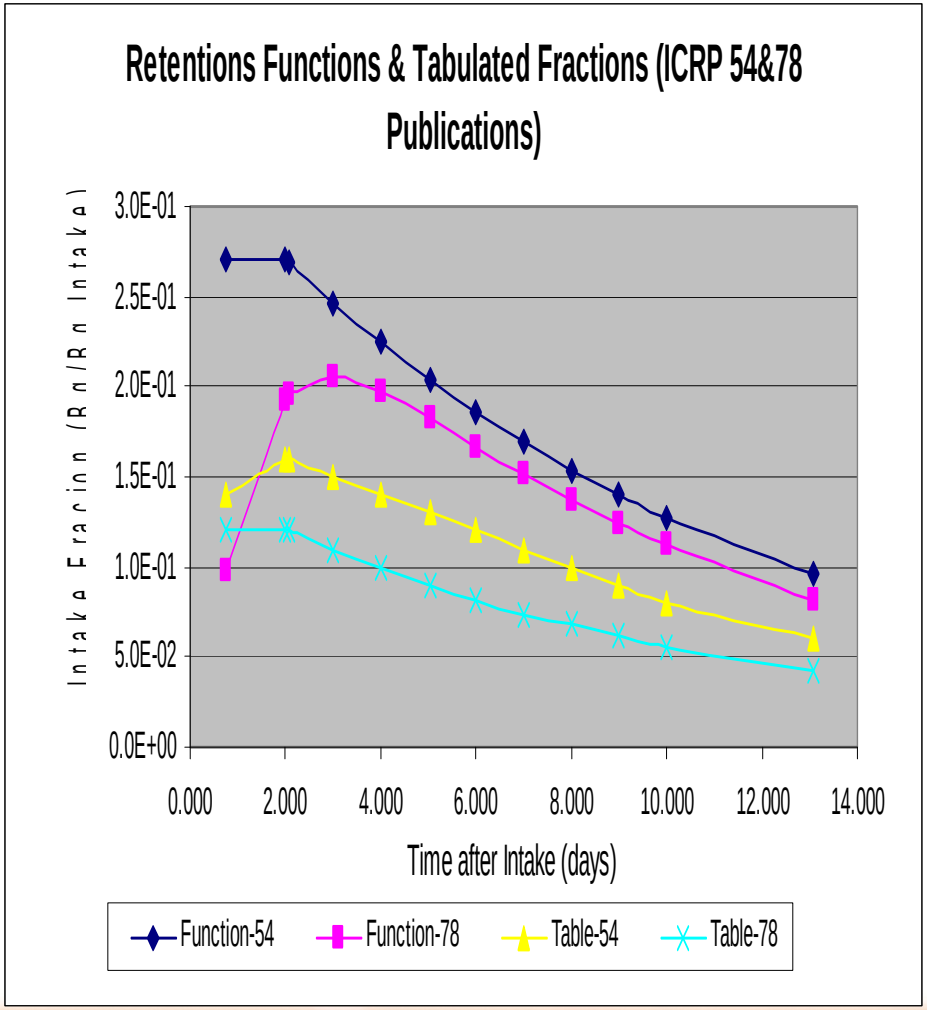
METHODS:

- Derived the retention function ($^{78}R_{Th,B}$), using the parameters of thyroid 3-compartmental model described in ICRP78 publication.
- Compared the similar retention function ($^{54}R_{Th,B}$) of ICRP54.
- Simulated both functions over same period of time and plotted/compared outcomes.
- Plotted and compared the values of predicted Intake Fraction, given in both ICRP 54 and 78.
- Compared $^{78}R_{Th,B}$ and $^{54}R_{Th,B}$ with Predicted Intake Factions (PIF).
- Applied PIF and RF to thyroid measurements of two subjects and obtained their Intakes, which then evaluated.
- Applied dose conversion factor (ICRP68, 1.1x10-8 Sv.Bq-1) and tissue weighting factor (W_T = 0.05) to derive the Committed Effective Dose (CED) and thyroid dose equivalent.

RESULTS: Retentions & PIF Values

Table 1: Comparison between Thyroid Retentions Functions and Tabulated PIF Values of ICRP 54 and 78 Publications

Elapsed Time (h)	m(t)				Elapsed Time (d)
	ICRP 54		ICRP 78		
	Retention Function	Tabulated Fractions	Retention Function	Tabulated Fractions	
18.1	2.70E-01	1.40E-01	9.72E-02	0.120	0.753
48.0	2.70E-01	1.60E-01	1.93E-01	0.120	2.000
49.8	2.69E-01	1.60E-01	1.95E-01	0.120	2.075
72.0	2.47E-01	1.50E-01	2.05E-01	0.110	3.000
96.0	2.24E-01	1.40E-01	1.97E-01	0.099	4.000
121.0	2.03E-01	1.30E-01	1.82E-01	0.090	5.040
144.0	1.86E-01	1.20E-01	1.67E-01	0.082	6.000
168.0	1.69E-01	1.10E-01	1.51E-01	0.074	7.000
192.0	1.54E-01	1.00E-01	1.37E-01	0.068	8.000
216.0	1.40E-01	9.00E-02	1.24E-01	0.062	9.000
240.0	1.28E-01	8.00E-02	1.12E-01	0.056	10.000
314.0	9.56E-02	6.00E-02	8.21E-02	0.043	13.085



RESULTS: Subjects Intakes

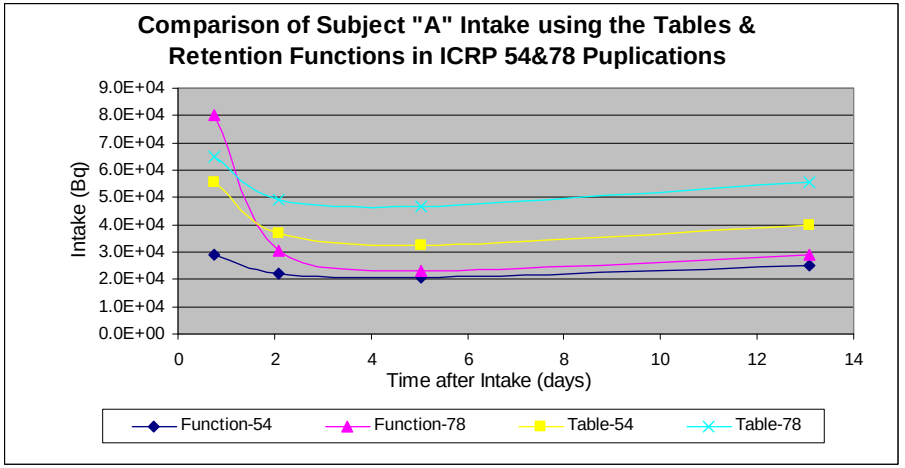
Comparison between I-131 Intakes of Two Contaminated Subjects, using the Biokinetic Models and Tabled Fractions in ICRP 54&78 Publications.

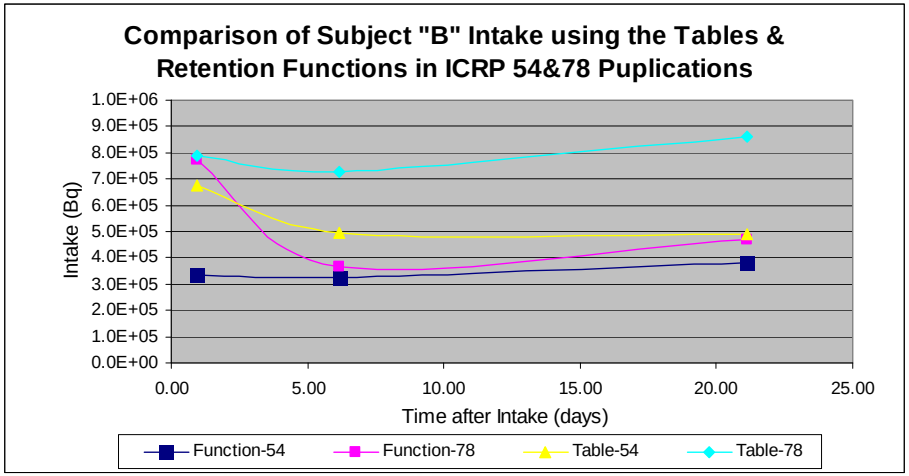
Table 2: I-131 Intake (A0) by subject "A":

Measured Activity (M)		Function-54	Table-54	Function-78	Table-78
Elapsed days	**M (Bq)**	**A0 (Bq)**	**A0 (Bq)**	**A0 (Bq)**	**A0 (Bq)**
0.753	7800	2.89E+04	5.57E+04	8.02E+04	6.50E+04
2.075	5900	2.20E+04	3.69E+04	3.03E+04	4.92E+04
5.04	4200	2.06E+04	3.23E+04	2.31E+04	4.67E+04
13.09	2400	2.51E+04	4.00E+04	2.92E+04	5.58E+04
Statistical Comparison	**Mean**	**2.41E+04**	**4.12E+04**	**4.07E+04**	**5.42E+04**
	SD	**3.66E+03**	**1.02E+04**	**2.65E+04**	**8.19E+03**
	%SD	**15.18**	**24.65**	65.19	**15.12**

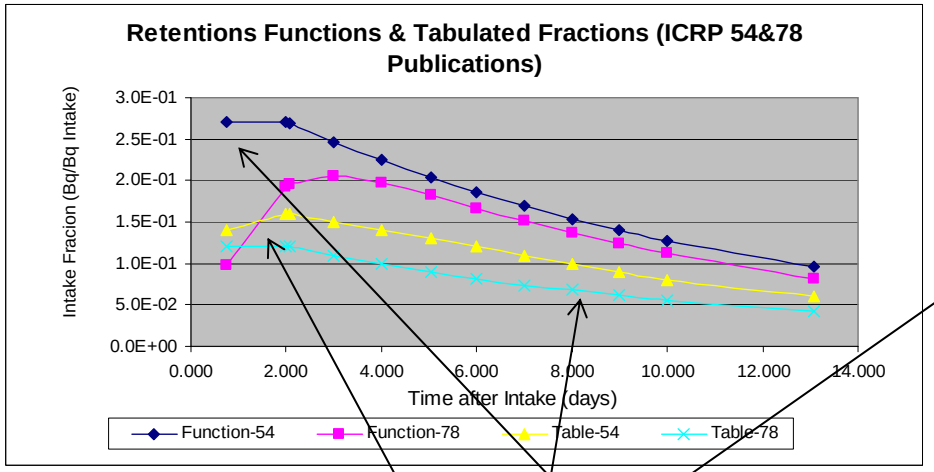
Table 3: I-131 Intake (A0) by subject "B"

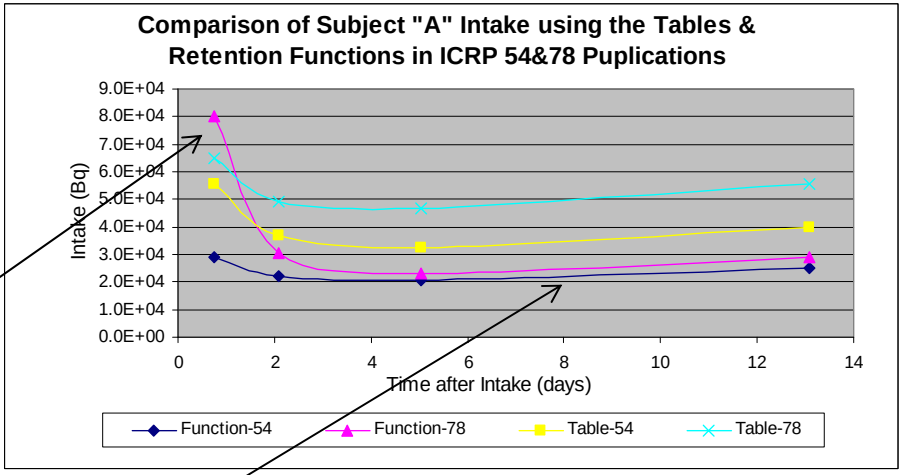
Measured Activity (M)		Function-54	Table-54	Function-78	Table-78
Elapsed days	**M (Bq)**	**A0 (Bq)**	**A0 (Bq)**	**A0 (Bq)**	**A0 (Bq)**
0.07	[illegible]	[illegible]	-	[illegible]	-
0.94	94390	3.37E+05	6.74E+05	7.74E+05	7.87E+05
6.17	59690.0	3.26E+05	4.97E+05	3.63E+05	7.28E+05
21.11	17200	3.80E+05	4.91E+05	4.67E+05	8.60E+05
Statistical Comparison	**Mean**	**3.48E+05**	**5.54E+05**	**5.35E+05**	**7.92E+05**
	SD	**2.84E+04**	**1.04E+05**	**2.13E+05**	**6.62E+04**
	%SD	**8.16**	**18.73**	**39.91**	**8.36**



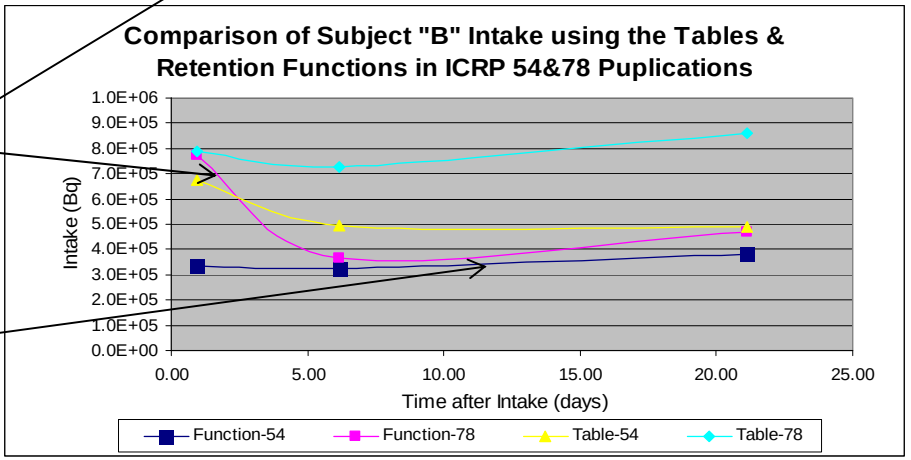


RESULTS: RF & PIF versus Intakes





- The steep plots' sections of A & B resulted from the Build Up (BU) of RF & PIF.
- The flat BU of $^{54}R_{Th,B}$ resulted in minimum fluctuations to the intakes of A&B subjects.
- The sharp BU of $^{78}R_{Th,B}$ is due to $^{78}\lambda \sim< 3\ ^{54}\lambda$.
- BU region results in an over estimation of Intake.
- Intake's trend by Retention Functions or PIF is steady after the BU region and would have less uncertainty of average.



CONCLUSIONS:

- Over the steady region, $^{78}R_{Th,B} < {}^{54}R_{Th,B}$ (slightly) hence gives a higher predicted Intake.
- Difference between the values of RF versus PIF in each publication existed.
- Values of PIF are smaller than corresponding RF in both publications i.e. resulting in higher predicted intake.
- $^{54}R_{Th,B}$ is less sensitive to “transfer time” and compatible with the default 0.25d value, in contrast with $^{78}R_{Th,B}$ and PIFs.
- Incident with potentially high intake shall require multiple measurements (over a period of time) to establish the uptake peak, hence obtaining a reliable intake average.

CONCLUSIONS: (Continue….)

- The predicted Intake at 2 days or less showed significant variations by both $^{78}R_{Th,B}$ and PIFs thus, suggesting a need for longer "transfer time" in which the uptake can reach its maximum and minimise the uncertainty in intake's average.
- The PIF plots of ICRP 54&78 publications follow similar trend after ~3 days of the intake.
- The deviations of average intake by ICRP 54&78 ranged between 15% to 65% for subject "A"; and 8% to 40% for subject "B". The BU contributes largely to this variations.
- "Transfer time" to reach uptake maxima of subjects "A" & "B" showed one fold deviation e.g. ~2 versus 4. This may be related to different individual metabolism!!

References:

1. ICRP Publication 54, Pergamon Press, 1988.
2. ICRP Publication 78, Pergamon Press, 1998.
3. ICRP Publication 68, Pergamon Press, 1995.
4. ANSTO files of the subjects.
5. Mathematical Models in Biology, L Edelstein-Keshet, 1988, Random House/NY.
6. Elementary Differential Equations with Boundary Value Problems, C H Edwards, et al., 2nd Ed, 1989.

THANKS FOR YOUR ATTENTION

QUESTIONS????????