



## STUDY OF VARIATION OF EFFECTIVE ATOMIC NUMBERS WITH PHOTON ENERGY FOR DNA AND RNA IN DIFFERENT METHODS

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### Abstract:

The Effective atomic number of a bio molecule present in DNA, RNA for photon interaction has been estimated in the energy range 0.001- 20MeV using two different methods. The significant variation of  $Z_{\text{eff}}$  with photon energy is reported and its values obtained from two methods are compared.

### Introduction:

Mass attenuation co-efficient ( $\mu/\rho$ ) is a measure of probability of interaction that occur between a photon and a matter of unit mass per unit area. The extent to which the biological system gets affected due to ionizing radiation depends on  $\mu/\rho$ . DNA and RNA are genetic materials found in chromosomes. The Gamma radiation causes damages to these genetic materials due to radiation-induced mutation in ova and sperm cells. The estimation of  $Z_{\text{eff}}$  for these molecule helps in characterizing the bio molecule. DNA and RNA are used first time in the present work. In the present study, bio molecules such as adenine, guanine, cytosine, thymine, the different components of DNA, uracil, one of the component of RNA are used and  $Z_{\text{eff}}$  of them at various photon energies (E) is estimated and compared using the following two theoretical methods. Method1 is used by many of the workers in the past, where as method 2 is a recent one.

### Method:1

The attenuation cross section for  $\mu/\rho$  of an element,  $\sigma$  is given by (Hubbell.J.H *et al*, 1995)

$$\sigma = \left(\frac{\mu}{\rho}\right) \left(\frac{A}{N}\right) \quad (1)$$

where, A is the atomic weight of the element and N is the Avogadro number.

Using theoretical values of  $\mu/\rho$  tabulated by Hubbell for different elements of atomic number (Z),  $\sigma$  may be estimated for each element at each E. A graph between  $\sigma$  and Z may be obtained.

The mass attenuation co-efficient of a compound or a mixture (bio-molecule) consists of various elements is given by mixture rule (Jackson F *et al*, 1981)

$$\left(\frac{\mu}{\rho}\right)_{\text{bio}} = \sum_i W_i \left(\frac{\mu}{\rho}\right)_i \quad (2)$$

where,  $\left(\frac{\mu}{\rho}\right)_i$  and  $W_i$  are mass attenuation co-efficient and fractional abundance by weight of  $i^{\text{th}}$  element present in a molecule respectively.

The cross section for  $(\mu/\rho)_{bio}$  of a bio molecule is given by

$$\sigma_{bio} = \frac{(\mu/\rho)_{bio}}{N \sum_i (W_i/A_i)} \quad (3)$$

where,  $A_i$  is the atomic weight of the  $i^{\text{th}}$  element in a molecule

Shivaramu (2002) estimated  $(\mu/\rho)_{bio}$  for various human tissues and organs using theoretical  $\mu/\rho$  of elements tabulated by Hubbell using expression (2). He estimated  $\sigma_{bio}$  using expression (3) and then  $Z_{\text{eff}}$  for the above bio molecule at each E by comparing the estimated  $\sigma_{bio}$  with the graph of  $\sigma$  versus Z.

### Method 2:

Orhan Icelli *et al*, (2004) estimated  $Z_{\text{eff}}$  of vanadium and nickel compounds for photon interaction as follows.

$(\mu/\rho)_{bio}$  is given by expression (2) and its molecular cross section  $\sigma_m$  is given by

$$\sigma_m = \left(\frac{1}{N}\right) \left(\frac{\mu}{\rho}\right)_{bio} \sum_i n_i A_i \quad (4)$$

where,  $n_i$  is the number of atoms of  $i^{\text{th}}$  element in a given molecule.

The atomic cross section  $\sigma_a$  and electronic cross section  $\sigma_e$  are given respectively by

$$\sigma_a = \frac{\sigma_m}{\sum_i n_i} \quad (5)$$

$$\sigma_e = \left(\frac{1}{N}\right) \sum_i \left\{ \left(\frac{f_i A_i}{Z_i}\right) \left(\frac{\mu}{\rho}\right)_i \right\} \quad (6)$$

where,  $f_i$  is the fractional abundance and  $Z_i$  is the atomic number of  $i^{\text{th}}$  element in a molecule respectively.

The effective atomic number is then given by

$$Z_{\text{eff}} = \frac{\sigma_a}{\sigma_e} \quad (7)$$

### Present work:

The molecular formulae of various bio molecules used in the present study are  $C_5H_5N_5$ ,  $C_5H_5ON_5$ ,  $C_4H_5ON_3$ ,  $C_5H_6O_2N_2$ ,  $C_4H_4O_2N_2$ ,  $C_5H_{10}O_4$  and  $C_{20}H_{28}O$  for Adenine, Guanine, Cytosine, Thymine, Uracil and deoxyribose, The theoretical  $Z_{\text{eff}}$  estimated using both the methods for the above bio molecules at various photon energies ranging from 0.001-20MeV are compared in the following figures 1-6

Fig.1 Adenine

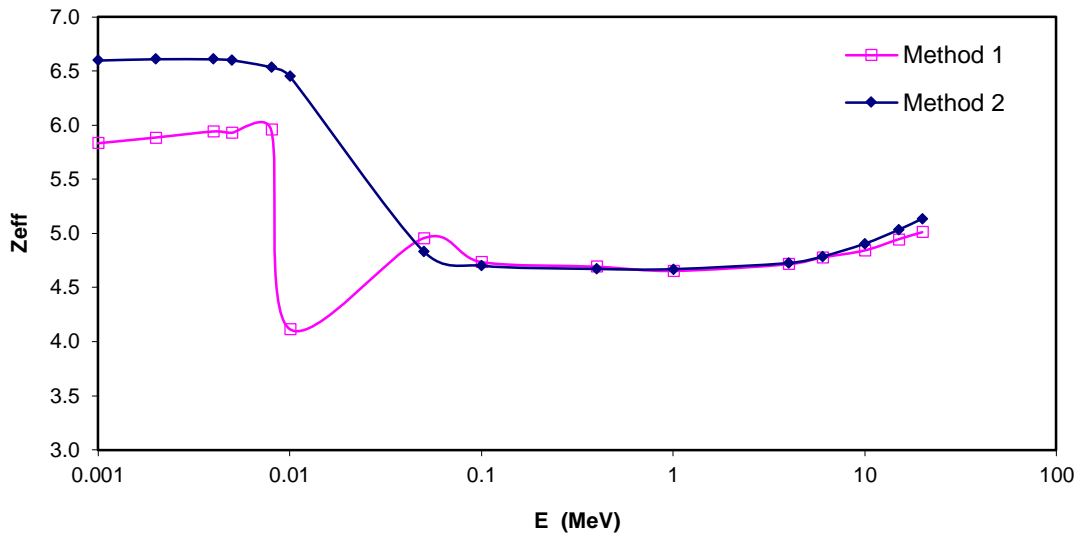


Fig. 2 Guanine

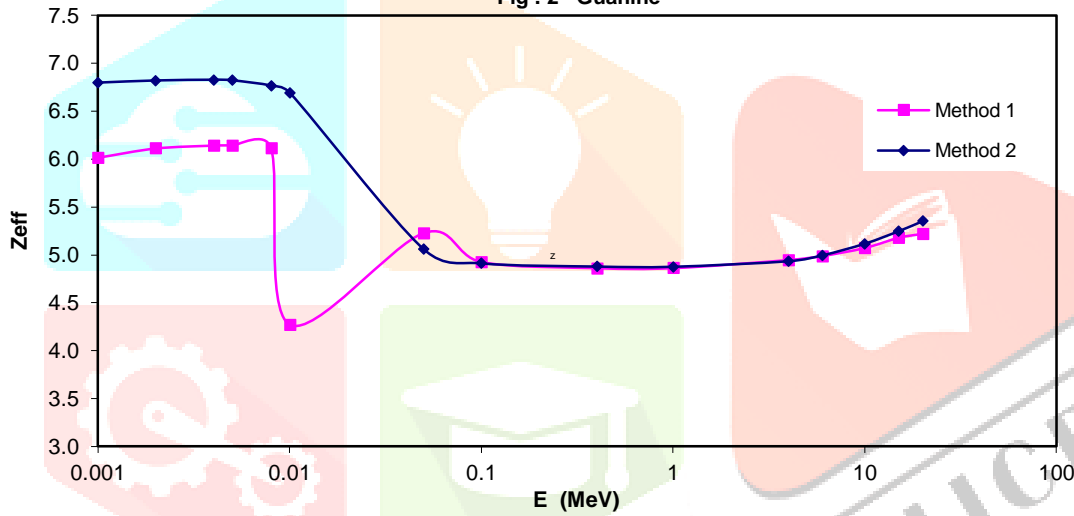


Fig.3 Thymine

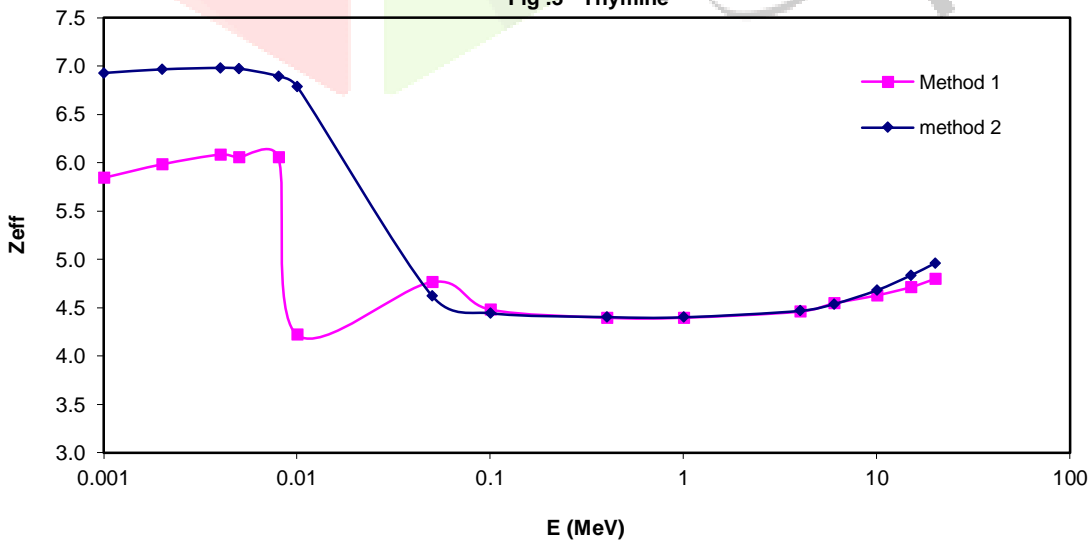


Fig . 4 Deoxyribose

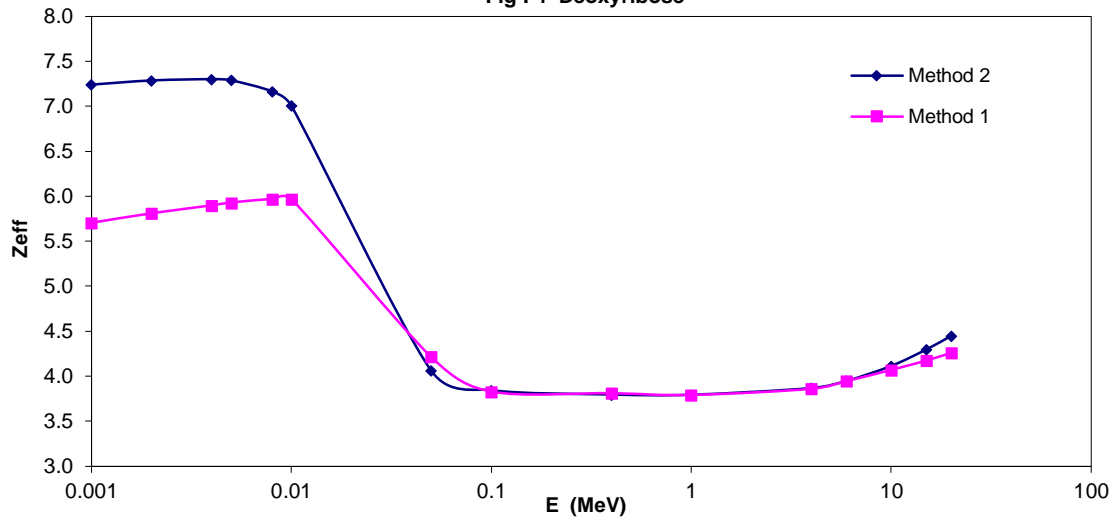


Fig . 5 Cytocine

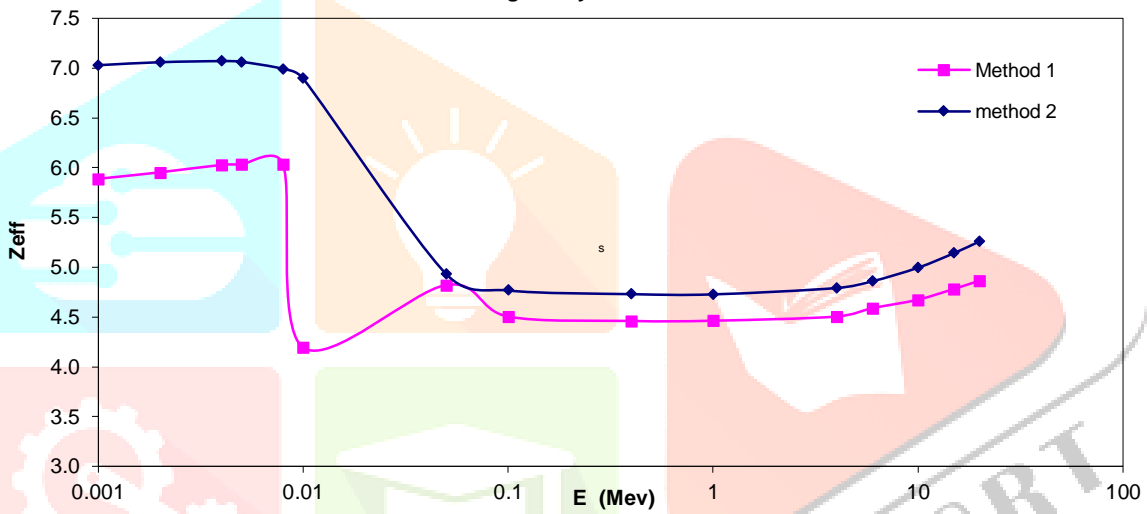
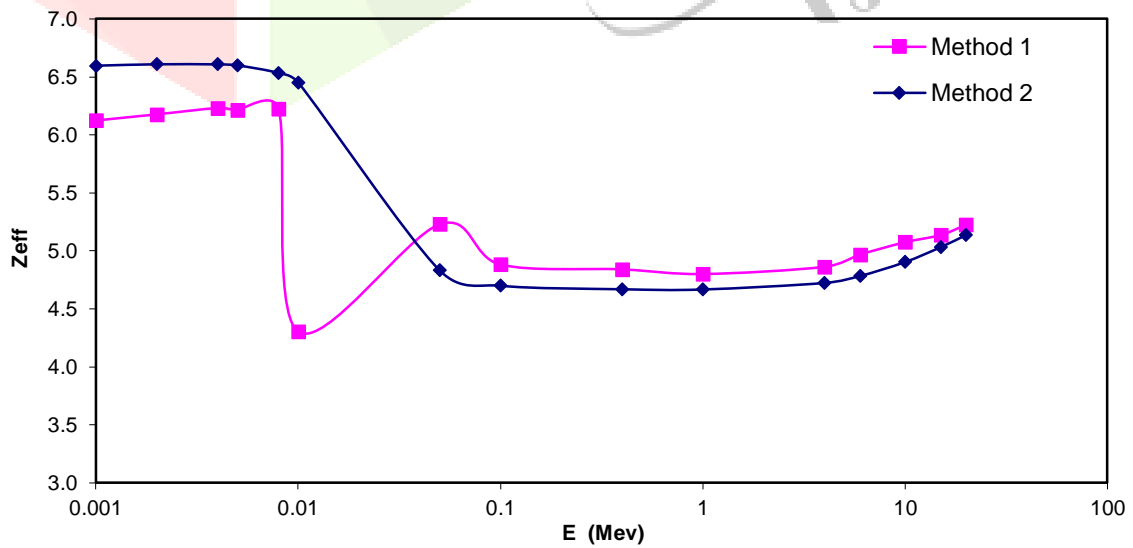


Fig . 6 Uracil



**Results and Discussion:**

In the case of DNA (Fig1-5), it is observed that both the methods disagree up to the photon energy range 0.001-0.1MeV for  $Z_{\text{eff}}$  and agree very well thereafter, except in cytocine (Fig-6) where in, there is a complete disagreement at all energies. For photon energy range 0.001-0.1 MeV  $Z_{\text{eff}}$  is found to be higher for method 2 than method 1. In case of RNA (Fig-7), same trend is observed as seen in DNA up to the photon energy range 0.001-0.1MeV ,thereafter difference is less. Even here,  $Z_{\text{eff}}$  is found to be higher for method 2 than method 1. In both the methods,  $Z_{\text{eff}}$  is found to vary throughout..

**References**

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