Where $\gamma^2 = \frac{1}{1-\beta^2}$, I is the mean excitation energy of the absorber $I = \hbar\omega$. One of the difficult parameters to evaluate in the above expression is the ionization potential I of the medium. For this a number of empirical formulas have been [7]:

$I = 12 + 7,\ Z_2 < 13$ ….. (4)
$I = 9.76Z_2{+}5.58Z_2^{-0.19}, Z_2 \geq 13$ ….. (5)

With the inclusion the corection terms B is now written as [11]:

$B(Z_1) = B_\circ + Z_1L_1 + L_2(Z_1) + [G(Z_1,\beta) - \delta(\beta)]/2$ ….. (6)

Where
$B_\circ(\beta) = f(\beta) - lnI - \frac{C\,(\beta)}{Z_2}$ ….. (7)

Where *C (β)* is the total shell correction, *G* (Z_1, *β*) the mott correction, *δ* the correction for the density effect, $L_1$the Barkas correction term, and L_2 the Bloch correction term [11].Many experimental as well as theoretical studies have been made with the object of establishing standard range energy relations.The subject has been reviewed in last two decades by several authors such as Taylor, Bethe and Askin, Allision and Warshaw, Uehling and by Barkas and Berger. Most of the experimental data has been compiled by Whaling and Bichsel in the form of tables. There have been several discussions and compilations on the energy - loss and range of heavy charged particles. Most of the work either depends on the use of fairly complicated semiempirical formulas derived from the Bethe-Bloch expression of stopping power or on entirely empirical formulas extracted from the experimental information. The old empirical formulas are in great error due. To lack of correct experimental information at that time. Moreover some relations are valid only for specific values of Z and in a small energy region. A. K. Chaubey and H. V. Gupta arrived at the following empirical relation for the stopping power of protons [12]:

$-\frac{dE}{\rho dx} = \frac{a}{A_2} E^{-b} Z_2^{clogE\,+d}$ ….. (8)

The appropriate values of the constants *a*, *b*, *c*, and *d* are *a* = 915.0, *b* = 0.85, *c* = 0.145, *d* = 0.635.Here *ρ*, *A* and Z_2 denote the density, atomic weight and atomic number of the stopping material while *E* is the kinetic energy of the particle in MeV/amu. The eq. (8) is found to be valid in the energy region 0.7 to 12 MeV/amu. The stopping power is in $MeVcm^2/gm$. The constants *c* and *d* are found to be independent of particle type and were obtained by fitting Northcliffe and Schilling (here after referred to as NS) stopping power values by the least squares method while the constants *a* and *b* were extracted using the experimental data of Whaling and Anderson et al. and also NS data towards lower energies. The stopping power for the ions heavier than protons can be found by the expressions given by Pierce and Blann [12,13]:

$\left(-\frac{dE}{\rho dx}\right)_H = \frac{z_{eff}^2}{\gamma_P^2}\left(-\frac{dE}{\rho dx}\right)_P$ ….. (9)

Where
$Z_{eff}^2 = \gamma^2 Z^2$

2. Results and Discussion

By using Bethe formula which represented in equation (2). We calculate the stopping power of protons with energy (1-12MeV) when passing in the atomic media (Be, C, Al and Cu) and we have arrived at the following semi empirical relation for the stopping power of protons for that four atomic media:

$S_e = abE^{-1}$ ….. (10)

Where

$a = 96\,\frac{Z_2}{A} + 3lnE$

$b = ln\left(104 \times 10^2 \times \frac{E}{I}\right)$

We programming this equation depended on Matlab program. As well as we using the SRIM2012 program to calculate the stopping power of protons in this atomic media and by using coincidence tool (curve fitting tool), we achieved finding equation (11) with its constants in any medium of four element :

Table 1: The equation which represent the stopping power of protons in (Be, C, Al and Cu)

Energy		Function	Element	Constant
1-12MeV	Power2	$f(x) = ax^b + c$ $S_e = aE^b + c$ ….. (11)	Be	a = 229.2 b = -0.7113 c = -6.795
			C	a = 242.1 b = -0.6641 c = -11.53
			Al	a = 185.9 b = -0.6197 c = -10.77
			Cu	a = 132.8 b = -0.5135 c = -13.71

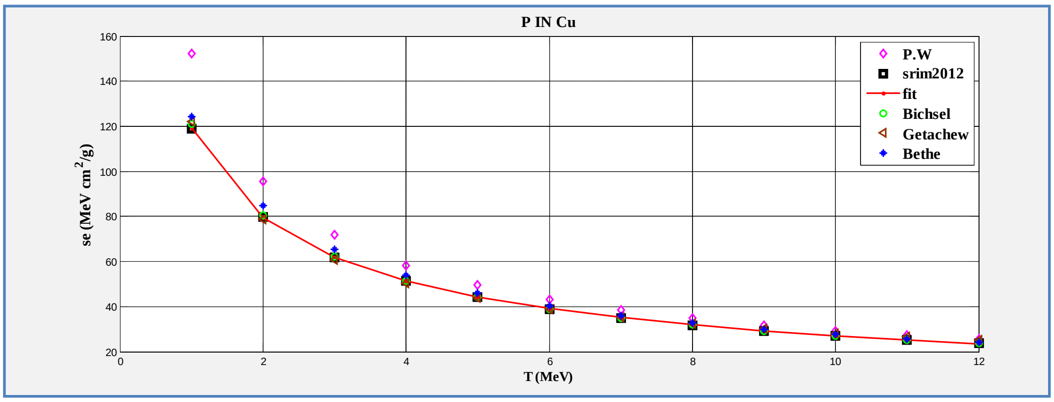

Figure 4: Stopping power of proton versus energy in Copper with others workers value.

3. Conclusions

From this research we can conclude several conclosion as follows:

1. The maximum value of stopping power occurs of lower energies of protons.
2. From the calculation of stopping power for proton using mathematical formulas (Bethe and semi empirical) we conclude that the stopping power inversely proportional with energy.
3. From the statistical test k, it can be concluded that the semi empirical relation do not agreed with the result of other ways of stopping compare with it of protons incident on Cu.

References

[1] T. Nandi et.al, "Fast Ion Surface Energy Loss and Straggling in the Surface Wake Fields", Physical Review Letters, PRL 110, 163203 (2013).
[2] M.C. Tufan and H. Gumus, "Stopping Power Calculations of Compounds by Using Thomas-Fermi-Dirac-Weizsacker Density Functional", Acta Physisa Polonica A, Vol. 114, No. 4, p703, (2008).
[3] P.L. Grande, G. Schiwietz, "The unitary convolution approximation for heavy ions", Nuclear Instruments and Methods in Physics Research B 195, p (55–63) (2002).
[4] S. Giordanengo, "Design, implementation and test of the hardware and software for the Fast Control of the Dose Delivery System of Centro Nazionale di Adroterapia Oncologica (CNAO)", University of Degli, 2009.
[5] H. Tai et.al, “Comparison of Stopping Power and Range Databases for Radiation Transport Study", National Aeronautics and Space Administration Langley Research Center. Hampton, Virginia 23681-2199,NASA Technical Paper 3644,p1 (1997).
[6] A. Csete, "Experimental Investigations of The Energy Loss of Slow Protons and Antiprotons in Matter", M.Sc. Thesis, Institute of Physics And Astronomy, University of Aarhus, p (1-8) (2002).
[7] S. N. Ahmed," physics and Engineering of Radiation Detection ", University of Queen's,p (118-120), (2007).
[8] M. Mayer, "Rutherford Backscattering Spectrometry (RBS)", Max-Planck-Institute Plasma physic, Euratom Association, (2003).
[9] J. Petola,"Stopping Power for Ions and Clusters In Crystalline Solids", University of Halsinki, Report Series In Physics, HU-P-D108, 8-14 (2003).
[10] V. Ivanchenko, "Hadron and Ion Ionization", Physics Reference Manual, (2007).
[11] H. Bichsel,"Stopping Powr and Ranges Of Fast Ions In Heavy Elements", Phys. Rev. A, Vol.46,No.9, 5761-5772 (1992).
[12] K. Chaubey and H. V. Gupta, " New empirical relations for stopping power and range of charged particles ", revue de physique appliquée, Vol. 12, p (321-329), (1977).
[13] A. Getachew, "Stopping Power and Range of Protons of Various Energies in Different Material", M.Sc. Thesis,University of Addis Ababa, (2007)