Computation of Randic index and Multiplicative Randic index for Human Chain Graph

Anitha K
[1]Department of Mathematics, Sri Sairam Engineering College, Chennai – 600 044, India

Abstract

The Randic index is denoted by $R(G)$, which is very applicable in chemistry and medicine. The mathematical foundation of this index is also extensively developed. In this paper, we compute the Randic index and multiplicative index for the interesting Human chain graph by using MATLAB.

Keywords: Randic index, Multiplicative Randic Index , Human chain graph, Correlation coefficient

1. Introduction

The Randic index, commonly known as the connectedness index, is a degree-based topological index studied extensively by Milan Randic [5] in 1976. It is defined as

$$R(G) = \sum_{uv \in E} \frac{1}{\sqrt{d(u) * d(v)}}$$

where $d(u)$ is the degree of the vertex u and uv is an edge of the graph G. The Randic index is very applicable in chemistry and medicine. It is commonly used in chemistry and pharmacology to create quantitative structure-property and structure-activity relationships. Randic's books [7, 8] and surveys [3,6,10] provide detailed information on these applications. Additional information about the Randic index can be found in Li and Shi's survey [9] or Li and Gutman's book [4]. Anitha, one of the author of this article, first introduced the human chain graph with another author, Selvam, in 2021 [1]. Additional information about the Human chain graph can be found in [2]. Again, the graph shows that we are interested in investing in the Randic index.

2. Explanation of the structure of the human chain graph

Consider $HC_{n,m}$, a human chain graph with 2mn+n+1 vertices and 2mn+2n edges for n≥ 1 and m≥ 3. The vertices are labeled as $u_1, u_2, \dots, u_{2n+1}, v_1, v_2, \dots, v_{(m-1)n}, w_1, w_2, \dots, w_{mn}$ and the edges are
$\{u_i u_{i+1} / 1 \le i \le 2n\} \cup \{u_{2i} v_{(m-1)(i-1)+1}, u_{2i} v_{(m-1)i}, u_{2i} w_{m(i-1)+1} / 1 \le i \le n\} \cup \{v_{(m-1)(i-1)+j} v_{(m-1)(i-1)+j+1} / 1 \le i \le n, 1 \le j \le m-2\} \cup \{w_{m(i-1)+j} w_{m(i-1)+j+1} / 1 \le i \le n, 1 \le j \le m-2\} \cup \{w_{mi} w_{mi-2} / 1 \le i \le n\}$.

The degree of each vertex is clearly understandable based on the topology of the human chain network. That means,

d(u_1)=1, d(u_{2n+1})=1,

For i= 1 to n,

d(u_{2i})=5, d(w_{mi})=1, d(w_{mi-1})=1, d(w_{mi-2})=3.

For i= 1 to n, j=1 to m−1

d($v_{(m-1)(i-1)+j}$)=2

For i= 1 to n, j=1 to m−3

d($w_{m(i-1)+j}$)=2

if m>3, For i= 1 to n−1,

d(u_{2i+1})=2.

Table−1 As a result, the number of vertices at 1 degree, 2 degree, 3 degree, and 5 degree of the given graph is listed below.

Number of 1−degree vertices	Number of 2−degree vertices	Number of 3−degree vertices	Number of 5−degree vertices
2n+2	2mn−3n−1	n	N

3. Determination of Randic Index and Multiplicative Randic Index

In this section, we will find the formulas and values of Randic index and multiplicative Randic index using MATAB for human chain graph .

3.1 Computing d(u)*d(v) for the Human Chain Graph's edges
If $n \geq 1$

$d(u_1) * d(u_2)$=1*5=5

$d(u_{2n}) * d(u_{2n+1})$=1*5=5

$d(u_{2i}) * d\left(v_{(m-1)(i-1)+1}\right)$=5*2=10, for $1 \leq i \leq n$

$d(u_{2i}) * d\left(v_{(m-1)i}\right)$=5*2=10, for $1 \leq i \leq n$

$d\left(v_{(m-1)(i-1)+j}\right)*\mathrm{d}(v_{(m-1)(i-1)+j+1})$= 2*2=4, for $1 \leq i \leq n, 1 \leq j \leq m-2$

$d(w_{mi})*\mathrm{d}(w_{mi-2})$= 1*3=3, for $1 \leq i \leq n$

$d(w_{mi-1})*\mathrm{d}(w_{mi-2})$= 1*3=3, for $1 \leq i \leq n$

$d(u_{2i})*\mathrm{d}(w_{m(i-1)+1})=\begin{cases}5*2=10, \text{for } 1 \leq i \leq n, \mathrm{m}>3 \\ 5*3=15, \text{for } 1 \leq i \leq n, \mathrm{m}=3\end{cases}$

If m>3,

$d\left(w_{m(i-1)+j}\right)*\mathrm{d}(w_{m(i-1)+j+1})$= 2*2=4, for $1 \leq i \leq n, 1 \leq j \leq m-4$

$d(w_{mi-2})*\ d(w_{mi-3})$= 3*2=6, for $1 \leq i \leq n,$

If n>1,

$d(u_{2i})*d(u_{2i+1})$=2*2=4, for $1 \leq i \leq n-1$

$d(u_{2i+1})*d(u_{2i+2})$=2*2=4, for $1 \leq i \leq n-1$

Theorem 3.1 For $n \geq 1$, the Randic index for the human chain graph is

$$R(G)=\frac{2}{\sqrt{5}}+\frac{2n}{\sqrt{3}}+\frac{n}{\sqrt{15}}+\frac{2(2n-1)}{\sqrt{10}}+\frac{n}{2} \quad \text{for m=3}$$

$$R(G)=\frac{2}{\sqrt{5}}+\frac{2n}{\sqrt{3}}+\frac{n}{\sqrt{6}}+\frac{(5n-2)}{\sqrt{10}}+n \quad \text{for m=4}$$

$$R(G)=\frac{2}{\sqrt{5}}+\frac{2n}{\sqrt{3}}+\frac{n}{\sqrt{6}}+\frac{(5n-2)}{\sqrt{10}}+n(m-3) \quad \text{for m>4}$$

Proof

Let G represent a human chain graph.

We remember that, $R(G)=\sum_{uv \in E} \frac{1}{\sqrt{d(u)d(v)}}$, where uv is an edge.

We calculate the following by applying 3.1(Computing d(u)*d(v) for the edges of the Human Chain Graph).

If m=3, $R(G) = \frac{1}{\sqrt{d(u_1)*d(u_2)}} + \frac{1}{\sqrt{d(u_{2n})*d(u_{2n+1})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d(v_{(m-1)(i-1)+1})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d(v_{(m-1)i})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi})*\mathrm{d}(w_{mi-2})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-1})*\mathrm{d}(w_{mi-2})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*\mathrm{d}(w_{mi-2})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(v_{(m-1)i})*d(v_{(m-1)(i-1)+1})}} + \sum_{i=1}^{n-1} \frac{1}{d(u_{2i})*d(u_{2i+1})} + \sum_{i=1}^{n-1} \frac{1}{d(u_{2i+1})*d(u_{2i+2})}$

$= \frac{1}{\sqrt{5}} + \frac{1}{\sqrt{5}} + \frac{n-1}{\sqrt{10}} + \frac{n-1}{\sqrt{10}} + \frac{n}{\sqrt{10}} + \frac{n}{\sqrt{10}} + \frac{n}{\sqrt{3}} + \frac{n}{\sqrt{3}} + \frac{n}{\sqrt{15}} + \frac{n}{\sqrt{4}}$

Hence, $R(G) = \frac{2}{\sqrt{5}} + \frac{2n}{\sqrt{3}} + \frac{n}{\sqrt{15}} + \frac{2(2n-1)}{\sqrt{10}} + \frac{n}{2}$

If m=4,

$R(G) = \frac{1}{\sqrt{d(u_1)*d(u_2)}} + \frac{1}{\sqrt{d(u_{2n})*d(u_{2n+1})}} + \sum_{i=1}^{n-1} \frac{1}{d(u_{2i})*d(u_{2i+1})} + \sum_{i=1}^{n-1} \frac{1}{d(u_{2i+1})*d(u_{2i+2})} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d(v_{(m-1)(i-1)+1})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d(v_{(m-1)i})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*\mathrm{d}(w_{m(i-1)+1})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi})*\mathrm{d}(w_{mi-2})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-1})*\mathrm{d}(w_{mi-2})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-2})*\mathrm{d}(w_{mi-3})}} + \sum_{i=1}^{n} \sum_{j=1}^{m-2} \frac{1}{\sqrt{d(v_{(m-1)(i-1)+j})*\mathrm{d}(v_{(m-1)(i-1)+j+1})}}$

$= \frac{1}{\sqrt{5}} + \frac{1}{\sqrt{5}} + \frac{n-1}{\sqrt{10}} + \frac{n-1}{\sqrt{10}} + \frac{n}{\sqrt{10}} + \frac{n}{\sqrt{10}} + \frac{n}{\sqrt{10}} + \frac{n}{\sqrt{3}} + \frac{n}{\sqrt{3}} + \frac{n}{\sqrt{6}} + \frac{n(m-2)}{\sqrt{4}}$

Hence, $R(G) = \frac{2}{\sqrt{5}} + \frac{2n}{\sqrt{3}} + \frac{n}{\sqrt{6}} + \frac{(5n-2)}{\sqrt{10}} + n$, m=4.

If m>4

$R(G) = \frac{1}{\sqrt{d(u_1)*d(u_2)}} + \frac{1}{\sqrt{d(u_{2n})*d(u_{2n+1})}} + \sum_{i=1}^{n-1} \frac{1}{d(u_{2i})*d(u_{2i+1})} + \sum_{i=1}^{n-1} \frac{1}{d(u_{2i+1})*d(u_{2i+2})} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d(v_{(m-1)(i-1)+1})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d(v_{(m-1)i})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*\mathrm{d}(w_{m(i-1)+1})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi})*\mathrm{d}(w_{mi-2})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-1})*\mathrm{d}(w_{mi-2})}} + \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-2})*\mathrm{d}(w_{mi-3})}} + \sum_{i=1}^{n} \sum_{j=1}^{m-4} \frac{1}{\sqrt{d(w_{m(i-1)+j})*\mathrm{d}(w_{m(i-1)+j+1})}} + \sum_{i=1}^{n} \sum_{j=1}^{m-2} \frac{1}{\sqrt{d(v_{(m-1)(i-1)+j})*\mathrm{d}(v_{(m-1)(i-1)+j+1})}}$

$= \frac{1}{\sqrt{5}} + \frac{1}{\sqrt{5}} + \frac{n-1}{\sqrt{10}} + \frac{n-1}{\sqrt{10}} + \frac{n}{\sqrt{10}} + \frac{n}{\sqrt{10}} + \frac{n}{\sqrt{10}} + \frac{n}{\sqrt{3}} + \frac{n}{\sqrt{3}} + \frac{n}{\sqrt{6}} + \frac{n(m-4)}{\sqrt{4}} + \frac{n(m-2)}{\sqrt{4}}$

Hence $R(G) = \frac{2}{\sqrt{5}} + \frac{2n}{\sqrt{3}} + \frac{n}{\sqrt{6}} + \frac{(5n-2)}{\sqrt{10}} + n(m-3)$

3.2 MATLAB code for determining the Randic index value for the human chain graph

For m=3,

```
n=;
```

(2/sqrt(5))+(2*n/sqrt(3))+(n/sqrt(15))+(2*(2*n-1)/sqrt(10))+(n/2)

For m=4,

n=;

(2/sqrt(5))+(2*n/sqrt(3))+(n/sqrt(6))+((5*n-2)/sqrt(10))+(n)

For m>4,

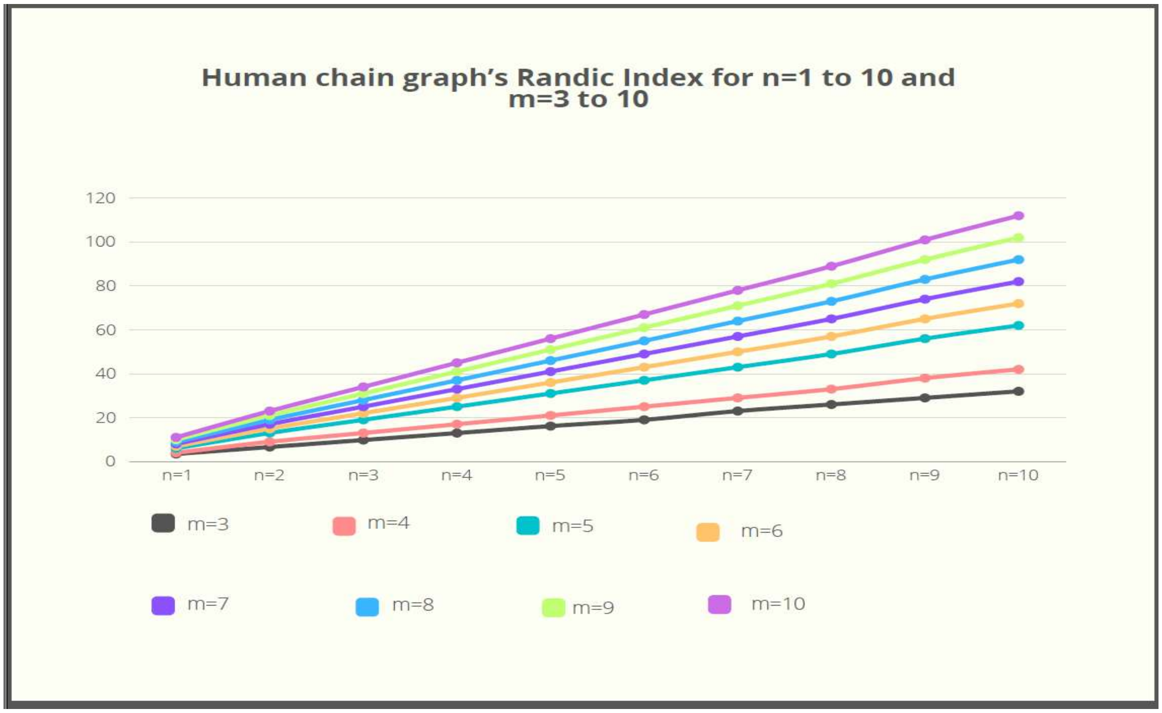
n=; m=;

(2/sqrt(5))+(2*n/sqrt(3))+(n/sqrt(6))+((5*n-2)/sqrt(10))+(n*(m-2))

Table−2 The human chain graph's Randic index for n = 1 to 10 and m = 3 to 10 is shown below.

	n=1	**n=2**	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**
m=3	3.4398	6.6176	9.7954	12.9732	16.1510	19.3288	22.5066	25.6844	28.8622	32.0400
m=4	4.406	8.5501	12.6942	16.8383	20.9824	25.1265	29.2706	33.4147	37.5588	41.7029
m=5	6.406	12.5501	18.6942	24.8383	30.9824	37.1265	43.2706	49.4147	55.5588	61.7029
m=6	7. 406	14.5501	21.6942	28.8383	35.9824	43.1265	50.2706	57.4147	64.5588	71.7028
m=7	8. 406	16.5501	24.6942	32.8383	40.9824	49.1265	57.2706	65.4147	73.5588	81.7028
m=8	9. 406	18.5501	27.6942	36.8383	45.9824	55.1265	64.2706	73.4147	82.5588	91.7028
m=9	10. 406	20.5501	30.6942	40.8383	50.9824	61.1265	71.2706	81.4147	91.5588	101.7028
m=10	11. 406	22.5501	33.6942	44.8383	55.9824	67.1265	78.2706	89.4147	100.5588	111.7028

The graph below shows the Randic index for n = 1-10 and m = 3-10.



Theorem 3.2 For $n \geq 1$, the Multiplicative Randic index for the human chain graph is

$$MR(G) = \left(\frac{1}{\sqrt{5}}\right)^2 * \left(\frac{1}{\sqrt{3}}\right)^{2n} * \left(\frac{1}{\sqrt{15}}\right)^n * \left(\frac{1}{\sqrt{10}}\right)^{4n-2} * \left(\frac{1}{2}\right)^n \quad \text{for m=3}$$

$$MR(G) = \left(\frac{1}{\sqrt{5}}\right)^2 * \left(\frac{1}{\sqrt{3}}\right)^{2n} * \left(\frac{1}{\sqrt{6}}\right)^n * \left(\frac{1}{\sqrt{10}}\right)^{5n-2} * \left(\frac{1}{2}\right)^{2n} \quad \text{for m=4}$$

$$MR(G) = \left(\frac{1}{\sqrt{5}}\right)^2 * \left(\frac{1}{\sqrt{3}}\right)^{2n} * \left(\frac{1}{\sqrt{6}}\right)^n * \left(\frac{1}{\sqrt{10}}\right)^{5n-2} * \left(\frac{1}{4}\right)^{n(m-3)} \quad \text{for m>4}$$

Proof

Let G represent a human chain graph.

We remember that, $R(G) = \prod_{uv \in E} \frac{1}{\sqrt{d(u)d(v)}}$, where uv is an edge.

We calculate the following by applying 3.1(Computing d(u)*d(v) for the edges of the Human Chain Graph).

If m=3, $MR(G) = \frac{1}{\sqrt{d(u_1)*d(u_2)}} * \frac{1}{\sqrt{d(u_{2n})*d(u_{2n+1})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d\left(v_{(m-1)(i-1)+1}\right)}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d\left(v_{(m-1)i}\right)}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi})*\mathrm{d}(w_{mi-2})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-1})*\mathrm{d}(w_{mi-2})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*\mathrm{d}(w_{mi-2})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d\left(v_{(m-1)i}\right)*d\left(v_{(m-1)(i-1)+1}\right)}} * \prod_{i=1}^{n-1} \frac{1}{d(u_{2i})*d(u_{2i+1})} * \prod_{i=1}^{n-1} \frac{1}{d(u_{2i+1})*d(u_{2i+2})}$

$= \frac{1}{\sqrt{5}} * \frac{1}{\sqrt{5}} * \left(\frac{1}{\sqrt{10}}\right)^{n-1} * \left(\frac{1}{\sqrt{10}}\right)^{n-1} * \left(\frac{1}{\sqrt{10}}\right)^{n} * \left(\frac{1}{\sqrt{10}}\right)^{n} * \left(\frac{1}{\sqrt{3}}\right)^{n} * \left(\frac{1}{\sqrt{3}}\right)^{n} * \left(\frac{1}{\sqrt{15}}\right)^{n} * \left(\frac{1}{\sqrt{4}}\right)^{n}$

Hence, $MR(G) = \left(\frac{1}{\sqrt{5}}\right)^{2} * \left(\frac{1}{\sqrt{3}}\right)^{2n} * \left(\frac{1}{\sqrt{15}}\right)^{n} * \left(\frac{1}{\sqrt{10}}\right)^{4n-2} * \left(\frac{1}{2}\right)^{n}$

If m=4,

$MR(G) = \frac{1}{\sqrt{d(u_1)*d(u_2)}} * \frac{1}{\sqrt{d(u_{2n})*d(u_{2n+1})}} * \prod_{i=1}^{n-1} \frac{1}{d(u_{2i})*d(u_{2i+1})} * \prod_{i=1}^{n-1} \frac{1}{d(u_{2i+1})*d(u_{2i+2})} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d\left(v_{(m-1)(i-1)+1}\right)}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d\left(v_{(m-1)i}\right)}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*\mathrm{d}(w_{m(i-1)+1})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi})*\mathrm{d}(w_{mi-2})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-1})*\mathrm{d}(w_{mi-2})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-2})*\mathrm{d}(w_{mi-3})}} * \prod_{i=1}^{n} \prod_{j=1}^{m-2} \frac{1}{\sqrt{d\left(v_{(m-1)(i-1)+j}\right)*\mathrm{d}(v_{(m-1)(i-1)+j+1})}}$

$= \frac{1}{\sqrt{5}} * \frac{1}{\sqrt{5}} * \left(\frac{1}{\sqrt{10}}\right)^{n-1} * \left(\frac{1}{\sqrt{10}}\right)^{n-1} * \left(\frac{1}{\sqrt{10}}\right)^{n} * \left(\frac{1}{\sqrt{10}}\right)^{n} * \left(\frac{1}{\sqrt{10}}\right)^{n} * \left(\frac{1}{\sqrt{3}}\right)^{n} * \left(\frac{1}{\sqrt{3}}\right)^{n} * \left(\frac{1}{\sqrt{6}}\right)^{n} * \left(\frac{1}{\sqrt{4}}\right)^{n(m-2)}$

Hence, $MR(G) = \left(\frac{1}{\sqrt{5}}\right)^{2} * \left(\frac{1}{\sqrt{3}}\right)^{2n} * \left(\frac{1}{\sqrt{6}}\right)^{n} * \left(\frac{1}{\sqrt{10}}\right)^{5n-2} * \left(\frac{1}{2}\right)^{2n}$

If m>4

$MR(G) = \frac{1}{\sqrt{d(u_1)*d(u_2)}} * \frac{1}{\sqrt{d(u_{2n})*d(u_{2n+1})}} * \prod_{i=1}^{n-1} \frac{1}{d(u_{2i})*d(u_{2i+1})} * \prod_{i=1}^{n-1} \frac{1}{d(u_{2i+1})*d(u_{2i+2})} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d\left(v_{(m-1)(i-1)+1}\right)}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*d\left(v_{(m-1)i}\right)}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(u_{2i})*\mathrm{d}(w_{m(i-1)+1})}} * \sum_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-2})*\mathrm{d}(w_{mi-3})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi})*\mathrm{d}(w_{mi-2})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-1})*\mathrm{d}(w_{mi-2})}} * \prod_{i=1}^{n} \frac{1}{\sqrt{d(w_{mi-2})*\mathrm{d}(w_{mi-3})}} * \prod_{i=1}^{n} \prod_{j=1}^{m-4} \frac{1}{\sqrt{d\left(w_{m(i-1)+j}\right)*\mathrm{d}(w_{m(i-1)+j+1})}} * \prod_{i=1}^{n} \prod_{j=1}^{m-2} \frac{1}{\sqrt{d\left(v_{(m-1)(i-1)+j}\right)*\mathrm{d}(v_{(m-1)(i-1)+j+1})}}$

$$= \frac{1}{\sqrt{5}} * \frac{1}{\sqrt{5}} * \left(\frac{1}{\sqrt{10}}\right)^{n-1} * \left(\frac{1}{\sqrt{10}}\right)^{n-1} * \left(\frac{1}{\sqrt{10}}\right)^{n} * \left(\frac{1}{\sqrt{10}}\right)^{n} * \left(\frac{1}{\sqrt{10}}\right)^{n} * \left(\frac{1}{\sqrt{3}}\right)^{n} * \left(\frac{1}{\sqrt{3}}\right)^{n} * \left(\frac{1}{\sqrt{6}}\right)^{n} * \left(\frac{1}{\sqrt{4}}\right)^{n(m-4)} * \left(\frac{1}{\sqrt{4}}\right)^{n(m-2)}$$

Hence $MR(G) = \left(\frac{1}{\sqrt{5}}\right)^{2} * \left(\frac{1}{\sqrt{3}}\right)^{2n} * \left(\frac{1}{\sqrt{6}}\right)^{n} * \left(\frac{1}{\sqrt{10}}\right)^{5n-2} * \left(\frac{1}{4}\right)^{n(m-3)}$

3.3 MATLAB code for determining the Multiplicative Randic index value for the human chain graph

For m=3,

```
n=;
(1/sqrt(5)^(2))*(1/sqrt(3)^(2*n))*(1/sqrt(15)^(n))*(1/sqrt(10)^ (4*n-2))*(1/2)^(n))
```

For m=4,

```
n=;
(1/sqrt(5)^(2))*(1/sqrt(3)^(2*n))*(1/sqrt(6)^(n))*(1/sqrt(10)^ (5*n-2))*(1/2)^(2*n))
```

For m>4,

```
n=; m=;
(1/sqrt(5)^(2))*(1/sqrt(3)^(2*n))*(1/sqrt(6)^(n))*(1/sqrt(10)^ (5*n-2))*(1/4)^(n*m-3))
```

Table−3 The human chain graph's Multiplicative Randic index for n = 1 to 8 and m = 3 to 6 is shown below.

	n=1	n=2	n=3	n=4	n=5	n=6	n=7	n=8
m=3	$8.6066e^{-04}$	$3.7037e^{-07}$	$1.5938e^{-10}$	$6.8587e^{-14}$	$2.9515e^{-17}$	$1.2701e^{-20}$	$5.4658e^{-24}$	$2.3621e^{-27}$
m=4	$2.1517e^{-04}$	$2.3148e^{-08}$	$2.4903e^{-12}$	$2.6792e^{-16}$	$2.8823e^{-20}$	$3.1009e^{-24}$	$3.3360e^{-28}$	$3.5890e^{-32}$
m=5	$3.3448e^{-05}$	$9.0422\ e^{-11}$	$6.0799\ e^{-16}$	$4.0881\ e^{-21}$	$2.7488\ e^{-26}$	$1.8483\ e^{-31}$	$1.2422\ e^{-36}$	$8.3563\ e^{-42}$
m=6	$3.3620e^{-06}$	$5.6514\ e^{-12}$	$9.4999\ e^{-18}$	$1.5969\ e^{-23}$	$2.6844\ e^{-29}$	$4.5124\ e^{-35}$	$7.5853e^{-41}$	$1.2751\ e^{-46}$

Based on the table 3 values, we can approximate all the values to 0. Therefore, we can deduce that the multiplicative random index equals 0.

Correlation coefficient between Randic index and Multiplicative Randic index
Let's take multiplicative Randic index values as Y and normalized Randic index values as X. It is evident that Y's mean value is 0. Consequently, since Y=0, the covariance of X and Y is zero. Therefore moreover, the correlation coefficient is zero. Hence there is no correlation between the Human chain graph's Randic index and Multiplicative index.

Conclusion
Using MATLAB, I determined the Randic and Multiplicative Randic indices for the human chain graphs that I had introduced. I found that there was no association between the two indices.

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