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On Some Topological Indices of the Triangular Snake Graph and Alternate Triangular Snake Graph

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ABSTRACT

The quantitative specifications which are used to narrate the atomic topology of graphs are usually entitled as topological indices in theoretical Chemistry. The features of physical and chemical properties like melting point, entropy, boiling point, energy generation and enthalpy of vaporization of chemical compounds can be estimated by means of these topological indices. The field of Graph theory has a remarkable application of linking certain graphs with many types of topological indices. In this paper we compute first and second Zagreb indices, Randi´c index, sum-connectivity index, harmonic index, inverse sum indeg index, modified first and second Zagreb indices and first and second hyper Zagreb indices of Triangular snake graph and alternate Triangular snake graph.
Keywords: Triangular snake graph, different topological indices.

I. INTRODUCTION

Chemical graph theory is a field which belongs to both mathematics and chemistry where it utilizes graph theory to model of chemical compound. The topological index is an invariable which illustrates the topology of molecular structure and converts it to a real number which estimates certain obvious properties like viscosity, freezing point, infrared spectrum, boiling point, melting point, density and electronic parameters which are termed as physico-chemical characteristics [1-3].

Graph theory has various branches, in which Chemical graph theory plays a very important role where a chemical compound is represented by simple graph called molecular graph in which atoms are vertices and atomic bonds are edges of a molecule. In recent times we see another emerging field that is Chem informatics, in which the relationship between structural property and quantitative structural activities are studied to predict biological activities of the structure.

In 1947 Weiner first introduced topological indices, it is a process in which the data related to chemical compounds is converted to some numerical values. These topological indices have many applications in the field of chemistry and graph theory, precisely in QSAR and QSPR studies. Topological indices are divided majorly in to eccentricity-based, degree-based, distance-based, spectrum-based, and so on. The degree-based topological indices are obtained by degrees of the vertices of the molecular graph of the corresponding chemical structures. Graph polynomials encode the information of a graph and build up various algebraic methods to find out the hidden information of a graph. Several important graph algebraic polynomials have been introduced. Some of them are Hosoye polynomial [7], Matching polynomial [8], M-polynomial [9], and so on.

II. PRELIMINARY CONCEPTS

Let G be a simple graph, with vertex set $V(G)$ and edge set $E(G)$ .The degree $d_g(u)$ of a vertex u is the number of edges that are incident to it. Since 1947 many number of topological indices have been found. One of the oldest and well known topological indices is the first and second Zagreb indices, was first introduced by Gutman et al. in 1972 [3], and it is defined as

$$M_1(G) = \sum_{uv\in E(G)} d_g(u) + d_g(v)$$

$$M_2(G) = \sum_{uv\in E(G)} d_g(u)d_g(v)$$

and the connectivity index introduced in 1975 by Milan Randi ́c [4], is defined as

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

Recently, another variant of the Randi ́c connectivity index called the sum-connectivity index $\chi(G)$was introduced by B. Zhou and N. Trinajsti ́c [5] in 2008. It is defined as

$$\chi(G) = \sum_{uv\in E(G)} \frac{1}{d_g(u) + d_g(v)}$$

In 2014 Jianxi Li and Chee Shiu introduced a new variant of the Randi ́c index named the Harmonic index which first appeared in [6] called the harmonic index $H(G)$ is defined as

$$H(G) = \sum_{uv\in E(G)} \frac{2}{d_g(u) + d_g(v)}$$

Discrete Adriatic indices have been defined by Vukičević and Gašperov in 2010 . One among such indices is the inverse sum indeg index, [7] and is defined as

$$ISI(G) = \sum_{uv\in E(G)} \frac{d_g(u)d_g(v)}{d_g(u) + d_g(v)}$$

A.Milicevi, S. Nikoli, N. Trinajstic, introduced in 2004 the modified first and second Zagreb indices [8], and are respectively defined as

$$mM_1(G) = \sum_{u\in V(G)} \frac{1}{\left(d_g(u)\right)^2}$$

$$mM_2(G) = \sum_{uv\in E(G)} \frac{1}{d_g(u)d_g(v)}$$

In 2013 , Shirdel et al. introduced the first hyperZagreb index of a graph G, which is defined as

$$H_{M1}(G) = \sum_{uv\in E(G)} \left(d_g(u) + d_g(v)\right)^2$$

The second hyper-Zagreb index of a graph G is defined as

$$H_{M2}(G) = \sum_{uv\in E(G)} \left(d_g(u)d_g(v)\right)^2$$

The ABC index of the graph G is defined as

$$\sum_{uv\in E(G)} \frac{\sqrt{d_g(u)+d_g(v)-2}}{d_g(u)d_g(v)}$$

The Somber index of the graph G is

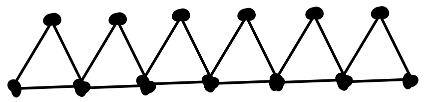
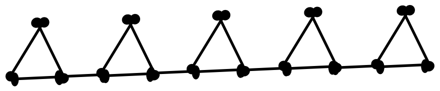
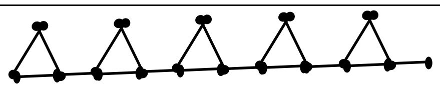
$$SDD(G) = \sum_{uv\in E(G)} \sqrt{\left(d_g(u)\right)^2 + \left(d_g(v)\right)^2}$$

The Geometric Arithemetic index is defined as

$$\sum_{uv\in E(G)} \frac{\sqrt{d_g(u)d_g(v)-2}}{d_g(u)+d_g(v)}$$

Definition 2.1: *Snake Graph and Alternate Triangular Snake graph*

The triangular snake T_n is obtained from the path P_n by replacing each edge of the path by a triangle C_3. An alternate triangular snake $A(T_n)$ is obtained from a path $u_1, u_2, ----, u_n$ by joining $u_i u_{i+1}$(alternately) to a new vertex v_i.

NAME OF THE GRAPH	I. GRAPH
SNAKE GRAPH T_7	
ALTERNATE SNAKE GRAPH $A(T_7)$	
ALTERNATE SNAKE GRAPH $A(T_8)$	

III. Main Results

In this paper we compute topological indices of snake graph and alternate snake graph.

Theorem 3.1: If $T_n, A(T_n)$ **is the Triangular and Alternate Triangular snake graphs, then**

$(i) M_1(\boldsymbol{T_n}) = 20\text{n} - 28$

$(ii) M_2(\boldsymbol{T_n}) = 32\text{n} - 56$

$(iii) mM_1(\boldsymbol{T_n}) = \dfrac{3n-1}{8}$

$(iv) HM_1(\boldsymbol{T_n}) = 136n - 232$

$(v) HM_2(\boldsymbol{T_n}) = 480n - 896$

$(vi) \chi(\boldsymbol{T_n}) = \dfrac{11n+1}{24}$

$(vii) R(\boldsymbol{T_n}) = \dfrac{n-1}{\sqrt{2}} + \dfrac{n+1}{4}$

$(viii) H(\boldsymbol{T_n}) = \dfrac{2n+3}{4} (ix) IsI(\boldsymbol{T_n}) = 3n - 3$

$(x) ABC(\boldsymbol{T_n}) = \dfrac{13n - 5 + \sqrt{6}}{4}$

$(xi) GAI(\boldsymbol{T_n}) = \dfrac{n-2}{2} + \dfrac{\sqrt{2}}{6}(4n - 7)$

$(xii) SO(\boldsymbol{T_n}) = (n-3)4\sqrt{2} + 4n\sqrt{5} - 6\sqrt{5} + \sqrt{8}$

Proof: Let $v_{1,} v_{2,} \ldots . v_n$ be the vertices of the path P_n of T_n and $v_1', v_2', \ldots . v_n'$ be the tip vertices of triangle with base vertices as $v_{i,} v_{i+1}$. There are (n-3) pairs of edges with degrees 4,4 ; (n+2) pairs of edges with degrees 4,2 and two pairs of edges with degrees 2,2 and 2,4.

With these degree sequences, we have

(i) $M_1(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} d(u) + d(v)$

$=(\text{n} - 3)(4 + 4) + (2\text{n} - 4)(2 + 4)$
$+2(2 + 2) + 2(4 + 2) = 20\text{n} - 28$

(ii) $M_2(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} d(u)d(v)$

$= \text{n} - 3)(4 \times 4) + (2\text{n} - 4)(4 \times 2)$
$+2(2 \times 2) + 2(2 \times 4) = 32\text{n} - 56$

(iii) $mM_2(\boldsymbol{T_n}) = \sum_{uv\epsilon E(G)} \frac{1}{d(u)d(v)}$

$= \frac{n-3}{4.2} + \frac{2n-4}{4.2} + \frac{2}{2.2} + \frac{2}{2.4} = \frac{3n-1}{8}$

(iv) $HM_1(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \big(d(u) + d(v)\big)^2$

$= (2\text{n} - 4).(4 + 2)^2 + (\text{n} - 3)(4 + 4)^2$
$+2(2 + 2)^2 + 2(2 + 4)^2$
$= 136n - 232$

$(v) HM_2(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \big(d(u)d(v)\big)^2$

$= 2\text{n} - 4).(4.6)2 + (\text{n} - 3)(4.4)2$
$+2(6.1)2 + 2(2.2)2 + 2(2.4)2$
$= 480n - 896$

$(vi) R(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \frac{1}{\sqrt{d(u)d(v)}}$

$= \frac{2n-4}{\sqrt{2.4}} + \frac{n-3}{\sqrt{4.4}} + \frac{2}{\sqrt{2.2}} + \frac{2}{\sqrt{4.2}} = \frac{n-1}{\sqrt{2}} + \frac{n+1}{4}$

Proof: Let $v_{1,} v_{2,} \ldots . v_n$ be the vertices of the path P_n of T_n and $v_1', v_2', \ldots . v_n'$ be the tip vertices of triangle with base vertices as $v_{i,} v_{i+1}$. There are (n-3) pairs of edges with degrees 4,4 ; (n+2) pairs of edges with degrees 4,2 and two pairs of edges with degrees 2,2 and 2,4.

With these degree sequences, we have

(i) $M_1(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} d(u) + d(v)$

$=(\text{n} - 3)(4 + 4) + (2\text{n} - 4)(2 + 4) + 2(2 + 2) + 2(4 + 2) = 20\text{n} - 28$

(ii) $M_2(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} d(u)d(v)$

$= n-3)(4\times 4) + (2n-4)(4\times 2) + 2(2\times 2) + 2(2\times 4) = 32n-56$

(iii) $mM_2(\boldsymbol{T_n}) = \sum_{uv\epsilon E(G)} \frac{1}{d(u)d(v)}$

$= \frac{n-3}{4.2} + \frac{2n-4}{4.2} + \frac{2}{2.2} + \frac{2}{2.4} = \frac{3n-1}{8}$

(iv) $HM_1(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \left(d(u)+d(v)\right)^2$

$= (2n-4).(4+2)^2 + (n-3)(4+4)^2 + 2(2+2)^2 + 2(2+4)^2$

$= 136n - 232$

$(v) HM_2(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \left(d(u)d(v)\right)^2$

$= 2n-4).(4.6)2 + (n-3)(4.4)2 + 2(6.1)2 + 2(2.2)2 + 2(2.4)2$

$= 480n - 896$

$(vi) R(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \frac{1}{\sqrt{d(u)d(v)}}$

$= \frac{2n-4}{\sqrt{2.4}} + \frac{n-3}{\sqrt{4.4}} + \frac{2}{\sqrt{2.2}} + \frac{2}{\sqrt{4.2}} = \frac{n-1}{\sqrt{2}} + \frac{n+1}{4}$

$(viii) \chi(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \frac{1}{d(u)+d(v)}$

$= \frac{2n-4}{4+2} + \frac{n-3}{4+4} + \frac{2}{2+2} + \frac{2}{2+4} = \frac{11n+1}{24}$

$(iX) ISI(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \frac{d(u)d(v)}{d(u)+d(v)}$

$= (2n-4)\frac{4.2}{4+2} + (n-3)\frac{4.4}{4+4} + 2\frac{2.2}{2+2} + 2\frac{2.2}{2+4} = \frac{10n-16}{3}$

$(X) ABC(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \frac{\sqrt{d(u)d(v)-2}}{d(u)d(v)}$

$= (2n-4)\frac{\sqrt{2.4-2}}{4+2} + (n-3)\frac{\sqrt{4.4-2}}{4+4} + 2\frac{\sqrt{2.2-2}}{2+2} = \frac{13n-5+\sqrt{6}}{4}$

$(Xi) GAI(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \frac{\sqrt{d(u)d(v)}}{d(u)+d(v)} = \frac{n-2}{2} + \frac{\sqrt{2}}{6}(4n-7)$

$(Xii). SO(\boldsymbol{T_n}) = \sum_{uv\epsilon E(g)} \sqrt{d(u)^2 + d(v)^2} = (n-3)4\sqrt{2} + 4n\sqrt{5} - 6\sqrt{5} + \sqrt{8}$

Theorem 3.2: If $A(T_n)$ is the Alternate Triangular snake graphs, then

$(i) M_1(A(\boldsymbol{T_n})) = 8n - 6$ *for odd n*, $12n - 12$ *for even n*

$(ii) M_2(A(\boldsymbol{T_n})) = 11n - 13$ *for odd n*, $20n - 28$ *for even n*

$(iii) mM_1(A(\boldsymbol{T_n})) = \frac{5n+1}{24}$ *for odd n*, $\frac{5n+2}{16}$ *for even n*

$(iv) HM_1(A(\boldsymbol{T_n})) = 89n - 138$ *for odd n*, $40n - 68$ *for even n*

$(v) HM_2(A(\boldsymbol{T_n})) = 89n - 145$ *for odd n*, $260n - 408$ *for even n*

$(vi) \chi(A(\boldsymbol{T_n})) = \frac{7n+1}{24}$ *for odd n*, $\frac{3n}{4}$ *for even n*

$(vii) R(A(\boldsymbol{T_n})) = \frac{3n}{4}$ *for odd n*, $\frac{3n}{4}$ *for even n*

$(viii) H(A(\boldsymbol{T_n})) = \frac{(n+1)\left(2(n-2)\sqrt{3} + 3\sqrt{3} + 6\right)}{6\sqrt{3}}$ *for odd n*, $\frac{2n+3}{4}$ *for even n*

$(ix) IsI(A(\boldsymbol{T_n})) = \frac{8n-7}{4}$ *for odd n*, $3n - 3$ *for even n*

$(x) ABC(A(\boldsymbol{T_n})) = \frac{\sqrt{2}(n+1)}{8} + \frac{\sqrt{2}}{3} + \frac{2(n-2)}{9}$ *for odd n*, $\frac{\sqrt{6}(n-2) + 2(n+1)}{8\sqrt{2}}$ *for even n*

$(xi) GAI(A(\boldsymbol{T_n})) = \frac{2n-3+\sqrt{3}}{2}$ *for odd n*, $2n - 1$ *for even n*

$(xii). SO(A(\boldsymbol{T_n})) = 4\sqrt{n} - 5\sqrt{2} + \sqrt{10}$ *for odd n*, $4\sqrt{2}(2n-1)$ *for even n*

Proof: Let $v_1, v_2, \ldots . v_n$ be the vertices of the path P_n of T_n and $v_1', v_2', \ldots . v_n'$ be the tip vertices of triangle with base vertices as v_i, v_{i+1}. We prove this in two cases.

***For odd n*:**

there are $\frac{n+1}{2}$ pairs of edges with degrees 2,2 ; (n-2) pairs of edges with degrees 3,3 and one pair of edge with degrees 3,1.

With these degree sequences, we have

$(i)\ M_1(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} d(u) + d(v)$

$=\frac{n+1}{2}(2+2)+(n-2)(3+3)+1(3+1)$

$= 8n-6$

$(ii) M_2(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} d(u)d(v)$

$=\frac{n+1}{2}(2.2)+(n-2)(3.3)+1(3.1)$

$= 11n-13$

$(iii)\ mM_2(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(G)} \frac{1}{d(u)d(v)}$

$= \frac{n+1}{2.2.2} + \frac{n-2}{3.3} + \frac{1}{3.1} = \frac{5n+1}{24}$

$(iv)\ HM_1(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} (d(u)+d(v))^2$

$= \frac{n+1}{2}.(2+2)^2+(n-2)(3+3)^2+1(3+1$

$= 89n-138$

$(v)\ HM_2(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} (d(u)d(v))^2$

$= (2n-4).(4.6)2+(n-3)(4.4)2 +2(6.1)2+2(2.2)2+2(2.4)2$

$= 480n-896$

$(vi)\ R(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{1}{\sqrt{d(u)d(v)}}$

$= \frac{n+1}{2}\frac{1}{2\sqrt{2}} + \frac{1}{\sqrt{3}} + \frac{n-2}{\sqrt{3.3}}$

$= \frac{7n-5}{12} + \frac{1}{\sqrt{3}}$

$(viii) \chi(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{1}{d(u)+d(v)}$

$= \frac{n+1}{2}\frac{1}{2+2} + \frac{1}{3+1} + \frac{n-2}{3+3}$

$= \frac{7n+1}{24}$

$(ix) ISI(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{d(u)d(v)}{d(u)+d(v)}$

$= \left(\frac{n+1}{2}\right)\frac{2.2}{2+2} + 1.\frac{3.1}{3+1} + (n-2)\frac{3.3}{3+3}$

$= \frac{8n-7}{4}$

$(x) ABC(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{\sqrt{d(u)d(v)-2}}{d(u)d(v)}$

$= \left(\frac{n+1}{2}\right)\frac{\sqrt{2+2-2}}{2.2} + 1.\frac{\sqrt{3+1-2}}{3.1} + (n-2)\frac{\sqrt{3+3-2}}{3.3}$

$= \frac{\sqrt{2}(3n+11)}{24} + \frac{2(n-2)}{9}$

$(xi) GAI(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{\sqrt{d(u)d(v)}}{d(u)+d(v)}$

$= \frac{1}{2}(2n-3+\sqrt{3})$

$(xii) SO(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \sqrt{d(u)^2+d(v)^2}$

$= 4n\sqrt{2} - 5\sqrt{2} + \sqrt{10}$

***For even n*:**

There are $\frac{n+4}{2}$ pairs of edges with degrees 2,2 ; (n-2) pairs of edges with degrees 3,3 .

With these degree sequences, we have

(i) $M_1(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} d(u)+d(v)$

$=\frac{n+4}{2}(2+2)+(n-2)(3+3)$

$= 8n+8$

(ii)$M_2(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} d(u)d(v)$

$=\frac{n+4}{2}(2.2)+(n-2)(3.3)$

$= 11n-10$

(iii) $mM_2(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(G)} \frac{1}{d(u)d(v)}$

$= \frac{n+4}{2.2.2} + \frac{n-2}{3.3} = \frac{17n+20}{72}$

(iv) $HM_1(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} (d(u)+d(v))^2$

$= \frac{n+4}{2}.(2+2)^2+(n-2)(3+3)^2$

$= 17n+14$

$(v) HM_2(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} (d(u)d(v))^2$

$= \frac{n+4}{2}.(2.2)^2+(n-2)(3.3)^2$

$= 89n+130$

$(vi) R(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{1}{\sqrt{d(u)d(v)}}$

$= \frac{n+4}{2}\frac{1}{\sqrt{2+2}} + \frac{n-2}{\sqrt{3+3}} = \frac{n+4}{4} + \frac{n-2}{\sqrt{6}}$

$(viii) \chi(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{1}{d(u)+d(v)}$

$= \frac{n+4}{2}\frac{1}{2+2} + \frac{n-2}{3+3} = \frac{7n+4}{24}$

$(ix) ISI(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{d(u)d(v)}{d(u)+d(v)}$

$= \left(\frac{n+4}{2}\right)\frac{2.2}{2+2} + (n-2)\frac{3.3}{3+3}$

$= 2n-1$

$(x) ABC(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{\sqrt{d(u)d(v)-2}}{d(u)d(v)}$

$= \left(\frac{n+4}{2}\right)\frac{\sqrt{2+2-2}}{2.2} + (n-2)\frac{\sqrt{3+3-2}}{3.3}$

$= \frac{\sqrt{2}(n+4)}{8} + \frac{\sqrt{5}(n-2)}{9}$

$(xi) GAI(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \frac{\sqrt{d(u)d(v)}}{d(u)+d(v)} = \frac{3n+6}{2}$

$(xii) SO(A(\boldsymbol{T_n})) = \sum_{uv\epsilon E(g)} \sqrt{d(u)^2+d(v)^2} = (10n-14)\sqrt{2}$

III. CONCLUSION

In this paper we computed first and second Zagreb indices, Randi´c index, sum-connectivity index, harmonic index, inverse sum indeg index, modified first and second Zagreb indices and first and second hyper Zagreb indices of the snake graph and alternating snake graph.

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