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Semi-Compact and Semi-*Lindelöf* Spaces via Neutrosophic Crisp Set Theory

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Abstract

The aim of this paper is devoted to introduce and study the concepts of semi-compact (resp. semi-Lindelöf, locally semi-compact) spaces in a neutrosophic crisp topological space. Several properties, functions properties of neutrosophic crisp semi-compact spaces are studied. In addition to these, we introduce and study the definition of neutrosophic crisp semi-Lindelöf spaces and neutrosophic crisp locally semi-compact spaces. We show that neutrosophic crisp semi-compact spaces is preserved under neutrosophic crisp irresolute function and neutrosophic crisp pre-semi-closed function with neutrosophic crisp semi-compact point inverses.

Keywords: Neutrosophic crisp semi-compact spaces, Neutrosophic crisp semi-Lindelöf spaces, Neutrosophic crisp locally semi-compact spaces**.** Neutrosophic topological spaces

1. Introduction and preliminaries

Neutrosophic Crisp Sets were introduced by Salama & Smarandache in 2015. Neutrosophic topological spaces and many applications have been investigated by Salama et al. [5, 7, 8, 9] and [11-21]. The notions and terminologies not explained in this paper may be found in [9]. Some definitions and results which will be needed in this paper are recalled here. *In this paper, we generalize the crisp semi-compact spaces* [1] *and some notions in [2, 3, 4, 6] to the notion of neutrosophic crisp semi-compact spaces.*

Definition 1.1 [9] For any non-empty fixed set X, a neutrosophic crisp set (NC-set, for short) A is an object having the form $A=\langle A_1, A_2, A_3\rangle$, where A_1, A_2 and A_3 are subsets of Xsatisfying$A_1\cap A_2=\emptyset$, $A_1\cap A_3=\emptyset$ and $A_3\cap A_2=\emptyset$.

Several relations and operations between NC-sets were defined in [8].

Definition 1.2 [9] A neutrosophic crisp topology (NCT, for short) on a non-empty set X is a family Γ of neutrosophic crisp subsets of X satisfying the following axioms

i) $\emptyset_N, X_N\in\Gamma$.
ii)$A_1\cap A_2\in\Gamma$ for any A_1 and $A_2\in\Gamma$.
iii) $\cup A_j\in\Gamma$ for any $\{A_j: j\in J\}\subseteq\Gamma$.

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In this case the pair (X, Γ) is called a neutrosophic crisp topological space ($NCTS$, for short) in X. The elements in Γ are called neutrosophic crisp open sets (NC-open sets for short) in X. A NC-set F is said to be neutrosophic crisp closed set (NC-closed set, for short) if and only if its complement $F^c$is a NC-open set.

Definition 1.3 [8] Let (X, Γ) be a $NCTS$ and A=⟨A_1, A_2, A_3⟩ be a NC-set in X. Then the neutrosophic crisp closure of A ($NCcl(A)$ for short) and neutrosophic crisp interior ($NCint(A)$ for short) of A are defined by:

(i) $NCcl(A)$=⋂ {K: K is a NC-closed set in X and A⊆K}

(ii) $NCint(A)$=⋃ {G: G is a NC-open set in X and G⊆A),

It can be also shown that $NCcl(A)$ is a NC-closed set, and $NCint(A)$ is a NC-open set in X.

Definition 1.4 [7] Let (X, Γ) be a $NCTS$ and A =⟨A_1, A_2, A_3⟩ be a NCS in X, then A is called:

i) Neutrosophic crisp α-open set iff $A \subseteq NCint(NCcl(NCint(A))$.

ii) Neutrosophic crisp semi-open set iff $A \subseteq NCcl\ (NCint\ (A))$.

iii)Neutrosophic crisp pre-open set iff $A \subseteq NCint(NCcl(A))$.

Definition 1.5 [3,10] A subset A of space X is called semi-compact relative to X if any semi-open cover of A in X has a finite subcover of A.

Definition 1.6 [10] A subset A of a space X is called semi-Lindelöf in X if any semi-open cover of A in X has a countable subcover of A.

Definition 1.7 [5] Let (X, Γ) be a $NCTS$ and A =⟨A_1, A_2, A_3⟩ be a NCS in X, then f: $X \longrightarrow X$ is NCsemi-continuous if the inverse image of NCsemi-open set is NCsemi- open.

2. Neutrosophic Crisp Semi-compact Spaces.

Definition 2.1 Let (X, Γ) be a $NCTS$.

(i) If a family {⟨G_{i_1},G_{i_2},G_{i_3}⟩: i∈I} of NC-semiopen sets in X satisfies the condition X_N= ⋃{⟨G_{i_1},G_{i_2},G_{i_3}⟩:i∈I}, then it is called a NC-semiopen cover of X.

(ii) A finite subfamily of a NC-semiopen cover {⟨G_{i_1},G_{i_2},G_{i_3}⟩: i=1,2, 3, …, n} on X, which is also a NC-semiopen cover of X, is called a finite sub cover of NC-semiopen sets.

Definition 2.2A $NCTS$ (X, Γ) is called neutrosophic crisp semi-compact spaces (NC-semi-compact , for short) if any NC-semiopen cover of X has a finite subcover.

Definition 2.3

A family {⟨k_{i_1},k_{i_2},k_{i_3}⟩:i∈I} of NC-semiclosed sets in X satisfies the finite intersection property (FIP for short) iff every finite subfamily {⟨k_{i_1},k_{i_2},k_{i_3}⟩:i=1, 2,3……,n} of the family satisfies the condition $\bigcap_i$ {⟨k_{i_1},k_{i_2},k_{i_3}⟩:i=1,2,3……,n}≠ Φ_N.

Theorem 2.4 A $NCTS$ (X, Γ) is NC-semi-compact iff every family {⟨G_{i_1},G_{i_2},G_{i_3}⟩: i∈I} of NC-semiclosed sets in X having the FIP has a nonempty intersection.

Proof. Let X be a NC-semi-compact space and $\mathcal{G}$={$\langle G_{i_1},G_{i_2},G_{i_3}\rangle$: i∈I}be a cover of NC-semiopen sets of X having the FIP. Suppose that$\bigcap_i$ {$\langle G_{i_1},G_{i_2},G_{i_3}\rangle$:$i$∈I}= Φ_N, then {$X\backslash\langle G_{i_1},G_{i_2},G_{i_3}\rangle$:$i$∈I} is a NC-semiopen cover of X and must contain a finite subcover {$X\backslash\langle G_{i_1},G_{i_2},G_{i_3}\rangle$: i=1,2,3……,n} for X. This implies that $\bigcap_i$ {$\langle G_{i_1},G_{i_2}, G_{i_3}\rangle$: i= 1,2, 3……, n} = Φ_N this contradicts our assumption that $\mathcal{G}$ has a FIP. Conversely, assume that X is not NC-semi-compact. Then there exists a NC-semiopen cover {$\langle G_{i_1},G_{i_2},G_{i_3}\rangle$:$i$∈I} for X, which contain a finite subcover for X. Thus, {$X\backslash\langle G_{i_1},G_{i_2},G_{i_3}\rangle$:$i$∈I} is a family of NC-semiclosed sets of X having the FIP. Moreover, we have $\bigcap_i$ {$X\backslash\langle G_{i_1},G_{i_2}, G_{i_3}\rangle$: i∈I}= Φ_N. This complete the proof.

Definition 2.5A subset u=$\langle u_1, u_2,u_3\rangle$ of a $NCTS$ (X, Γ) is called NC-semi-compact relative to X if any NC-semiopen cover of u in X has a finite subcover of u. By NC-semi-compact in X, we will mean NC-semi-compact relative to X.

Definition 2.6 A subset u=$\langle u_1, u_2,u_3\rangle$ of a $NCTS$ (X, Γ) is called NC-semi-Lindelöf in X if any NC-semiopen cover of u in X has a countable subcover of u.

Remark 2.7

Since the family of all $NC\alpha$-open subset of a $NCTS$ (X, Γ), denoted by Γ^{α} is NCT on X finer that Γ, then the family of all NC-semiopen subsets of (X,Γ^{α}) is equal to the family of all NC-semiopen subsets of (X,Γ^{α}). Hence, it easily to see that a NC-set u of (X, Γ) is NC-semi-compact (respNC-semi-Lindelöf) in X iff it is NC-semi-compact (resp. NC-semi-Lindelöf) in (X,Γ^{α}).

Theorem 2.8 The finite (resp. countable) union of NC-semi-compact (resp. NC-semi-Lindelöf) sets in a $NCTSX$ is a NC-semi-compact (resp. NC-semi-Lindelöf) in X.

Proof . obvious.

Lemma 2.9 Let u⊆v⊆X, where X is a $NCTS$. Then u is NC-semiopen set in v, if u is NC-semiopen set in X.

Theorem 2.10 Let v be a NC-preopen subset of a $NCTSX$ and u⊆v. If u is NC-semi-compact (resp. NC-semi-Lindelöf) in X, then u is NC-semi-compact (resp. NC-semi-Lindelöf) in v.

Proof. Suppose that $\mathcal{G}$= {$\langle G_{i_1},G_{i_2},G_{i_3}\rangle$: i∈I} is a cover of u by NC-semiopen sets in v. Using lemma 2.9, G_{i_j}=S_{i_j}∩ v for each i∈I, j=1,2,3,where S_{i_j} is NC-semiopen set in X for each i∈I, j=1,2,3. Thus ξ={$\langle S_{i_1},S_{i_2},S_{i_3}\rangle$: i∈I } is a cover of u by NC-semiopen set in X, but u is NC-semi-compact in X, so there exists i=1,2,3……,n, j=1,2,3. Such that $u\subseteq\bigcup_{i=1}^{n} S_{i_j}$ and thus $u\subseteq\bigcup_{i=1}^{n} (S_{i_j}\cap v)$ $=\bigcup_{i=1}^{n} G_{i_j}$.Hence u is NC-semi-compact in v.

The other case is similar.

Corollary 2.11 Let v be NC-open ($NC\alpha$-open) set of $NCTS$ and u⊆v, if u is NC-semi-compact (resp. NC-semi-Lindelöf) in X, then u is NC-semi compact (resp. NC-semi-Lindelöf) in v.

Proof. It is obviously, since each NC-open set is $NC\alpha$-open set and also NC-preopen set.

Lemma 2.12 Let $u\subseteq v\subseteq X$, where X is a $NCTS$ and v is a NC-preopen set in X, then u is NC-semiopen (resp. NC-semiclosed) in $v$iff$u= S\cap v$, where S is NC-semiopen (resp. NC-semiclosed) in X.

Proof. Obvious.

Theorem 2.13 Let v be a NC-preopen subset of $NCTSX$ and $u\subseteq v$. Then u is NC-semi compact (resp. NC-semi-Lindelöf) in Xiff$u$ is NC-semi compact (resp. NC-semi-Lindelöf) in v.

Proof. Necessity. It follows from Theorem 2.8 sufficiency. Suppose that $\xi= \{\langle S_{i_1}, S_{i_2}, S_{i_3}\rangle: i\in I\}$ is a cover of u be NC-semiopen sets in X. Then $\mathcal{G}= \{S_{i_j}\cap v: i\in I, j=1,2,3\}$ is a cover of u. Since S_{i_j} is NC-semiopen in X for each $i\in I$ and v is NC-preopen in X, it follows from Lemma 2.12 that $S_{i_j}\cap v$ is NC-semiopen set in v for each $i\in I$, j=1,2,3, but u is NC-semi-compact in v, so there exists $i\in I$, j=1,2,3 that $u\subseteq \bigcup_{i=1}^{n} S_{i_j}\cap v\subseteq \bigcup_{i=1}^{n} S_{i_j}$. Hence, u is NC-semi-compact in X.

The other case is similar.

Corollary 2.14 A NC-preopen subset u of X is NC-semi compact (resp. NC-semi-Lindelöf) iff$u$ is NC-semi compact (resp. NC-semi-Lindelöf) in X.

Corollary 2.15 A NC-open ($NC\alpha$-open) subset u of X is NC-semi compact (resp. NC-semi-Lindelöf) iff$u$ is NC-semi compact (resp. NC-semi-Lindelöf) in X.

Theorem 2.16 Let v be a NC-semi-compact (resp. NC-semi-Lindelöf) set in a $NCTSX$ and v be is NC-semiclosed of X. Then $u\cap v$ is NC-semi-compact (resp. NC-semi-Lindelöf) in X.

Proof. Suppose that $\mathcal{G}= \{G_{i_j}: i\in I, j=1,2,3\}$ is a cover of $u\cap v$ by NC-semiopen set in X. Then $\mathcal{G}= \{G_{i_j}: i\in I, j=1,2,3\} \cup\{X\backslash v\}$ is a cover of u by NC-semiopen sets in X, but u is NC-semi-compact in X, so there exists $i=$ 1.2.3……n, j=1.2.3 such that $u\subseteq (\bigcup_{i=1}^{n} S_{i_j})\cup\{X\backslash v\}$. Thus $u\cap v\subseteq \bigcup_{i=1}^{n} (S_{i_j}\cap v) \subseteq \bigcup_{i=1}^{n} S_{i_j}$. Hence, $u\cap v$ is NC-semi-compact in X.

The other case is similar.

Corollary 2.17A NC-semiclosed subset u of a NC-semi-compact (resp. NC-semi-Lindelöf) space X is NC-semi-compact (resp. NC-semi-Lindelöf) in X.

Remark 2.18 From the Definition 2.1 of NC-semi-compact space, one may deduce that: NC-semi-compact space $\Longrightarrow NC$-compact space, but the inverse direction may not be true in general as show by the following example.

Example 2.19 Let (X, Γ) be a $NCTS$, where X is infinite, and $\Gamma= \{X_N, \Phi_N\} \cup\{P\}$ where $P=\langle \{p_1\}, \{p_2\}, \{p_3\} \rangle$ be a NC-point in X. Then (X, Γ) is NC-compact but not NC-semi-compact, since $\{\langle \{x, p_1\}, \{x, p_2\}, \{x, p_3\} \rangle: x\in X\}$ is NC-semiopen cover of X which has no finite subcover.

3. Functions and Neutrosophic Crisp Semi-compact Spaces

Definition 3.1 A function f from a $NCTSX$ into a $NCTSY$ is called NC-irresolute if the inverse image of each NC-semiopen set in X, is a NC-semiopen set in Y.

Theorem 3.2 Let f:(X,Γ_1)⟶(Y,Γ_2) be a NC-irresolute function. Then
(i) If u is NC-semi-Lindelöf in X, then $f(A)$ is NC-semi-Lindelöf in Y.
(ii) If u is NC-semi-compact in X, then $f(A)$ is NC-semi-compact in Y.

Proof. We will proof (i) and (ii) is similar.

Suppose that $\mathcal{G}$= {⟨G_{i_j}⟩: i∈I, j=1, 2, 3} is a cover of $f(A)$ by NC-semiopen sets in Y. Then ℨ= {⟨$f^{-1}(G_{i_j})$⟩:i∈I, j=1,2,3} is a cover of u, but f is NC-irresolute function, so ⟨$f^{-1}(G_{i_j})$⟩ is NC-semiopen sets in X for each i∈I, j=1,2,3. Since u is NC-semi-Lindelöf in X, there exists i_1,i_2, i_3,…..,∈I such that $u\subseteq\bigcup_{i=1}^{\infty}\langle f^{-1}(G_{i_j})\rangle$. Thus $f(u)\subseteq\bigcup_{i=1}^{\infty}\langle f(f^{-1}(G_{i_j}))\ \rangle\subseteq\bigcup_{i=1}^{\infty}\langle G_{i_j}\rangle$. Hence, $f(A)$ is NC-semi-Lindelöf in X.

Corollary 3.3 If a function f:(X,Γ_1)⟶(Y,Γ_2) is a NC-irresolute (resp. NC-semi continuous) surjective and X is NC-semi-compact, then Y is NC-semi-compact (resp. NC-compact).

Definition 3.4 A function f from a $NCTSX$ into a $NCTSY$ is called NC-pre-semiopen (resp. NC-pre-semiclosed) if the image of each NC-semiopen (resp. NC-semiclosed) subsets of X is NC-semiopen (resp. NC-semiclosed) subsets of Y.

Theorem 3.5 Let f:(X,Γ_1)⟶(Y,Γ_2) be a NC-pre-semiclosed surjection. If for each NC-point y= ⟨{y_1},{y_2},{y_3}⟩ in Y, $f^{-1}(y)$=⟨f^{-1}{y_1},f^{-1}{y_2},f^{-1}{y_3}⟩ is NC-semi-compact (resp. NC-semi-Lindelöf) in X, then $f^{-1}(u)$ is NC-semi-compact (resp. NC-semi-Lindelöf) in X, where u is NC-semi-compact (resp. NC-semi-Lindelöf) in Y.

Proof. Will show the case when u is NC-semi-compact in X, the other case is similar. Let $\mathcal{G}$= {⟨$f^{-1}(\mathcal{G}_{i_j})$⟩:$i$∈I, j=1,2,3} is a cover of $f^{-1}(u)$ by NC-semiopen sets in X. Then it follows by assumption that for each NC-point y=⟨{y_1}, {y_2}, {y_3} ⟩ in Y, there exists a finite subcollection $\mathcal{G}_j^y$ of $\mathcal{G}$ such that $f^{-1}(y)\subseteq\cup\mathcal{G}_j^y$. Let H_{y_j}=$\cup\mathcal{G}_j^y$. Then H_y is NC-semiopen in X where any union of NC-semiopen sets is NC-semiopen. Let F_{y_j}= $Y\backslash f(X\backslash H_{y_j})$. Then $F_{y_j}$is NC-semiopen in Y where f is NC-pre-semiclosed, also y_i∈F_{y_j}; for each y_i∈u, since $f^{-1}(y)\subseteq H_{y_j}$. Thus the family {$H_{y_j}$:$y_j$∈$u$} is a cover of u by NC-semiclosed sets in Y, but u is NC-semi-compact in Y, so there exists y_1, y_2,…..,y_n∈u such that $u\subseteq\bigcup_{i=1}^{n}F_{y_{ij}}$, j=1,2,3. Thus $f^{-1}(u)\subseteq\bigcup_{i=1}^{n}f^{-1}(F_{y_{ij}})\subseteq F_{y_{ij}}$. Since $\mathcal{G}_j^{y_i}$ is a finite sub collection of $\mathcal{G}$ for each i=1,2, …..,n, j=1,2,3, it follows that $\bigcup_{i=1}^{n}\mathcal{G}_j^{y_i}$ is a finite sub collection of $\mathcal{G}$. Hence, $f^{-1}(u)$ is NC-semi-compact in X.

Corollary 3.6 Let f:(X,Γ_1)⟶(Y,Γ_2) be a NC-pre-semiclosed surjection. and $f^{-1}(y)$ is NC-semi-compact in X, for each NC-point y=⟨{y_1}, {y_2},{y_3}⟩ in Y. If Y is NC-semi-compact, so is X.

Definition 3.7 A $NCTS$ (X, Γ) is called NC-Hausdorff space if for each distinct NC-points$x$ and y of X, there exists two disjoint NC-open sets u and v of X containing x and y, respectively.

Theorem 3.8 Let f:(X,Γ_1)⟶(Y,Γ_2) is a NC-irresolute function from a NC-semi-compact space X into aNC-Hausdorff space Y, then

(i) f is NC-pre-semiclosed.

(ii) f is NC-semi-homomorphism if it is bijective.

Proof. Let u be a NC -semiclosed set of X. Then u is NC-semi-compact in X, (by Corollary 2.17). By Theorem 3.2, $f(u)$ is NC-semi-compact in Y and hence it is NC-semi-compact. Since Y is NC-Hausdorff, then $f(A)$ is NC-closed set in Y and NC-semiclosed. hence f is NC-pre-semiclosed.

(ii) Obvious.

4. Locally Neutrosophic Crisp Semi-compact Spaces

Definition 4.1 A $NCTSX$ is said to be locally neutrosophic crisp semi-compact (LNC-semi-compact, for short) if each NC-point of X has a NC-open neighborhood which is a NC-semi-compact X.

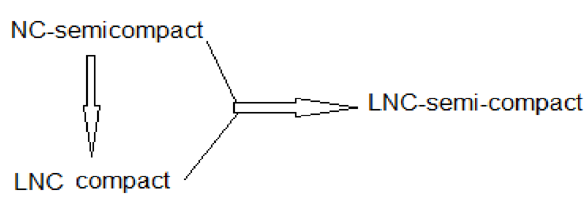
Remark 4.2 It is obvious that every NC-semi-compact space is LNC-semi-compact but the converse may not be true as show by the following example.

Example 4.3 Let (X, Γ) be an infinite discrete $NCTS$. It is obvious that (X, Γ) is LNC-semi-compact but not NC-semi-compact.

Remark 4.4 Every LNC-semi-compact space is LNC-compact, but the converse may not be true as shown by the following example.

Example 4.5 By Example 2.19 shows that a $NCTS$ (X, Γ) is LNC-compact but not LNC-semi-compact.

Remark 4.6 From the above discussion one can draw the following diagram:



Theorem 4.7 A $NCTSX$is LNC-semi-compact iff for each NC-point x∈X, there exists a NC-open set$u$ in X which is LNC-semi-compact containing$x$.

Proof. Let u= $\{\langle u_{i_1},u_{i_2},u_{i_3}\rangle$: i∈I$\}$ be a NC-open set in$X$ containing x=⟨{x_1}, {x_2}, {x_3} ⟩which is LNC-semi-compact. Then there exists a NC-open neighbourhood v= $\{\langle v_{i_1},v_{i_2},v_{i_3}\rangle$: i∈I$\}$ of x in u which is a NC-semi-compact in u. Since u is NC-open in X, so is v and by Corollary 2.11, v is NC-semi-compact in X. This shows that X is LNC-semi-compact.

The proof of the converse is obvious.

Theorem 4.8 A $NCTSX$is LNC-semi-compact iff for each NC-point of X has a NC-open neighbourhood which is LNC-semi-compact in X.

Proof. This follows from Corollary 2.15.

Theorem 4.9 Let f:(X, Γ_1)⟶(Y, Γ_2) be a NC-open, NC-semi continuous surjection. and X is LNC-semi-compact space, then Y is LNC-semi-compact.

Proof. For any NC-point $y \in Y$, there exists NC-point $x \in X$ such that $f(x)=y$. Since X is LNC-semi-compact, there exists a NC-open neighborhoodU_x of x which is NC-semi-compact in X. Hence $f(U_x)$ is NC-open neighborhood of y which is NC-semi-compact in Y. Therefore, by Theorem 4.8 is LNC-semi-compact.

Theorem 4.10 Let f:(X, Γ_1)⟶(Y, Γ_2) be a NC-pre-semiclosed, NC-continuous surjection. and $f^{-1}(y)$ is NC-semi-compact in X, for each NC-point $y \in Y$. If Y is LNC-semi-compact, so is X.

Proof. Let x is NC-point of X, by Theorem 4.8, there exists a NC-open neighborhood v of $f(x)$ such that v is NC-semi-compact in X. Then $f^{-1}(v)$ is a NC-open neighborhood of X. By Theorem 3.5, $f^{-1}(v)$ is NC-semi-compact in X. This shows that X is LNC-semi-compact.

5. Conclusion

The paper deals with the concept of semi-compact ness (resp. semi-Lindelöf) in the generalized setting of a neutrosophic crisp topological space. We achieve a number of a neutrosophic crisp semi-compact (resp. neutrosophic crisp semi-Lindelöf) space. Also, we introduce and study the concept of neutrosophic crisp locally semi-compact spaces.

References

[1] M. C. Cueva and J. Dontchev, "On spaces with hereditarily compact α-topologies," *ActaMathematicaHungarica*, vol. 82, no. 1-2, pp. 121–129, 1999.

[2] J. Dontchev and M. Ganster, "On covering spaces with semi-regular sets," *Ricerche di Matematica*, vol. 45, no. 1, pp. 229–245, 1996.

[3] C. Dorsett, "Semi-compactness, semiseparation axioms, and product spaces," *Bulletin of the Malaysian Mathematical Sciences Soceity*, vol. 4, no. 1, pp. 21–28, 1981.

[4] M. Ganster, "On covering properties and generalized open sets in topological spaces," *Mathematical Chronicle*, vol. 19, pp. 27–33, 1990.

[5] I.M.Hanafy, A.A.Salama, Hewayda ElGhawalby and M.S.Dabash, "Some GIS Topological Concepts via Neutrosophic Crisp Set Theory", To be published in the book titled *"New Trends in Neutrosophic Theories and Applications"*, Publisher: Europa Nova, Brussels, 2016.

[6] I. L. Reilly and M. K. Vamanamurthy, "On α-continuity in topological spaces, "Acta Mathematica Hungarica", vol. 45, no. 1-2, pp. 27–32, 1985.

[7] A.A.Salama, "Fuzzy Hausdorff spaces and fuzzy irresolute functions via fuzzy ideals", *V Italian-Spanish Conference on General Topology and its Applications* June 21-23, 2004 Almeria, Spain.

[8] A.A.Salama, F. Smarandache and ValeriKroumov. "Neutrosophic crisp Sets & Neutrosophic crisp Topological Spaces", *Neutrosophic Sets and System*, Vol. (2), (2014), 25-30

[9] A.A.Salama and Florentin Smarandache,"Neutrosophic crisp set theory", *Educational Publisher, Columbus*, (2015).USA.

[10] Mohammad S. Sarsak, "On Semi-compact Set and Associated Properties", *International Journal of Mathematics and mathematical sciences*, vol. 3, pp. 8, (2009).

[11] A. A. Salama, F. Smarandache, S. A Alblowi, New neutrosophic crisp topological concepts, Neutrosophic Sets and Systems 2 (2014) 50 – 54.

[12] A. A. Salama, Hewayda ElGhawalby, Asmaa.M.Nasr, Retract Neutrosophic Crisp System for Gray Scale Image, Asian Journal of Mathematics and Computer Research, ISSN No. : 2395-4205 (Print), 2395-4213 (Online), Vol.: 24, Issue.: 3, pp104-117

[13] Eman.M.El-Nakeeb, Hewayda ElGhawalby, A. A. Salama, S.A. El-Hafeez. (2017). Neutrosophic Crisp Mathematical Morphology, Neutrosophic Sets and Systems, Vol. 16, 57-69. http://fs.gallup.unm.edu/NSS/NeutrosophicCrispMathematicalMorphology.pdf

[14] A.A. Salama, Hewayda, ElGhawalby and Shimaa Fathi Ali. (2017). Topological Manifold Space via Neutrosophic Crisp Set Theory, Neutrosophic Sets and Systems, Vol.15, 18-21. http://fs.gallup.unm.edu/NSS/TopologicalManifoldSpace.pdf

[15] A. A. Salama, I. M. Hanafy, Hewayda Elghawalby, M. S. Dabash. (2016). Neutrosophic Crisp α-Topological Spaces, Neutrosophic Sets and Systems, vol. 12, 92-96. http://fs.gallup.unm.edu/NSS/NeutrosophicCrispAlphaTopologicalSpaces.pdf

[16] A. A. Salama, Said Broumi and Florentin Smarandache. (2014). Introduction to Neutrosophic Topological Spatial Region, Possible Application to GIS Topological Rules. I.J. Information Engineering and Electronic Business, 6, pp15-21. http://www.gallup.unm.edu/~smarandache/IntroductionToNeutrosophicTopological.pdf

[17] A. A. Salama. (2013). Neutrosophic Crisp Points & Neutrosophic Crisp Ideals, Neutrosophic Sets and Systems, Vol. 1, 50-53. http://fs.gallup.unm.edu/NSS/NeutrosophicCrispPointsNeutrosophic.pdf

[18] A. A. Salama, Florentin Smarandache. (2013). Filters via Neutrosophic Crisp Sets, Neutrosophic Sets and Systems, vol. 1, 34-37. http://fs.gallup.unm.edu/NSS/FiltersViaNeutrosophicCrispSets.pdf

[19] A.A. Salama, S.A. Alblowi. (2012). Generalized neutrosophic set and generalized neutrosophic topological spaces.Computer Science and Engineering. 2, 129-132. http://article.sapub.org/10.5923.j.computer.20120207.01.html

[20] A.A. Salama and S.A. Alblowi. (2012). Neutrosophic Set and Neutrosophic Topological Space, ISOR J. mathematics (IOSR-JM), 3 (4), 31-35. http://www.gallup.unm.edu/~smarandache/NeutrosophicSetAndNeutrosophic.pdf

[21] A. A. Salama. (2015). Basic Structure of Some Classes of Neutrosophic Crisp Nearly Open Sets & Possible Application to GIS Topology, Neutrosophic Sets and Systems, vol. 7, pp. 18-22. http://fs.gallup.unm.edu/NSS/BasicStructureOfSomeClasses.pdf