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On Neutrosophic Crisp Supra Topological Spaces

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***Abstract**: The aim of this paper is to introduce the concepts of closure, interior, neighbourhood, base and local base of neutrosophic crisp supra topological spaces and some of its characterizations are investigated.*

***Keywords:** Neutrosophic crisp supra topology, Neutrosophic crisp sets, Neutrosophic crisp supra open sets & neutrosophic crisp points.*

I. INTRODUCTION

Zadeh introduced the concept of fuzzy set [14] in 1965. In 1983 K.Atanassov [13] introduced generalization of fuzzy set intutionistic fuzzy set. Neutrosophy has the laid foundation for a whole family of new mathematical theories generalizing both their crisp and fuzzy counterparts, such as neutrosophic set theory [10, 9, 8].The idea of "neutrosophic set" was proposed by Smarandache [10, 8]. Neutrosophic operations have been developed by salama et al. [1, 3, 5, 7, 6, 4, 16, 11, 12, 1]. Salama and alblowi [3] define neutrosophic topological space and established some of its properties. Salama & Smarandache [2, 1, 10, 14] introduced the concepts of neutrosophic crisp sets, neutrosophic crisp operators have been investigated. In this paper we introduce the concepts of closure, interior, neighbourhood, base and local base of neutrosophic crisp supra topological spaces and some of its characterizations are investigated.

II. PRELIMINARIES

The definitions of neutrosophic crisp set (*NCS*), neutrosophic crisp types of $\varphi_N =<\varphi,\varphi,X>$ & $X_N =<X,\varphi,\varphi>$, neutrosophic crisp union , intersection, neutrosophic crisp subsets, neutrosophic crisp complement , family of union & intersection, neutrosophic crisp point and some properties of neutrosophic crisp sets was introduced by the authors [3,1].

III. NEUTROSOPHIC CRISP SUPRA TOPOLOGICAL SPACES

3.1. Definition:[16] A neutrosophic crisp supra topology (*NCST*) on a non empty set *X* is a family τ^{μ} of neutrosophic crisp subsets of *X* satisfying the following conditions:

(a) $\varphi_N , X_N \in \tau^{\mu}$

(b) $\bigcup E_i \in \tau^{\mu} \ \forall \ \{E_i : i \in I\} \subseteq \tau^{\mu}$

Then the pair (X,τ^{μ}) is called neutrosophic crisp supra topological space (*NCSTS).* Elements in τ^{μ} are called neutrosophic crisp supra open sets *(NCSOS)* and the complement of τ^{μ} are called neutrosophic crisp supra closed sets *(NCSCS).*

3.2. Example: Let $X=\{\delta_1,\eta_2,\psi_3,\sigma_4\}$, $\tau^{\mu}=\{\varphi_N,X_N,L,M,N\}$, where $L=<\{\delta_1,\eta_2\},\varphi,\{\psi_3\}>$, $M=<\{\delta_1,\eta_2\},\varphi,\{\sigma_4,\psi_3\}>$, $N=<\{\eta_2\},\varphi,\{\delta_1,\psi_3\}>$.Then (X,τ^{μ}) is a *NCSTS.*

3.3. Definition: Let (X,τ_1^{μ}) and (X,τ_2^{μ}) be two *NCSTSs* .We say that τ_1^{μ} is coarser than τ_2^{μ} or τ_2^{μ} is said to be finer than τ_1^{μ} ($\tau_1^{\mu} \subseteq \tau_2^{\mu}$) if $S \in \tau_2^{\mu}$ for every $S \in \tau_1^{\mu}$.

3.4. Definition: Let (X,τ^{μ}) be *NCSTS* and $E=<E_1,E_2,E_3>$ be any *NCS* of X then neutrosophic crisp supra closure of E *(NCS-cl (E))* and neutrosophic crisp supra interior *(NCS-int (E))* are defined by

(i) *NCS-cl (E)* $=\bigcap\{\lambda:\lambda$ is a *NCSCS* in X & $E\subseteq\lambda\}$.

(ii) *NCS-int* $(E)=\bigcup\{\lambda^*:\lambda^*$ is a *NCSOS* in X & $\lambda^*\subseteq E\}$.

3.5. Example: Let $X=\{\delta_1,\eta_2,\psi_3,\sigma_4\}$, $\tau^{\mu}=\{\varphi_N,X_N,L,M,N\}$, where $L=<\{\delta_1,\eta_2\},\varphi,\{\psi_3\}>$, $M=<\{\delta_1,\eta_2\},\varphi,\{\sigma_4,\psi_3\}>$, $N=<\{\eta_2\},\varphi,\{\delta_1,\psi_3\}>$.

Then (X,τ^{μ}) is a *NCSTS.*

Let $E=<\{\eta_2\},\varphi,\{\delta_1,\psi_3\}>$.

Then *NCS-int* $(E)=<\{\eta_2\},\varphi,\{\delta_1,\psi_3\}>$ and *NCS-cl (E)*$=<X,\varphi,\varphi>$.

3.6. Proposition: Let (X,τ^{μ}) be any *NCSTS*. If E and F are any *NCSs* of X Then the neutrosophic crisp supra closure operator satisfies the following.

(i) $E\subseteq$ *NCS-cl* (E).

(ii) $E\subseteq F\Rightarrow$ *NCS-cl* $(E)\subseteq$ *NCS-cl (F).*

(iii) *NCS-cl* $(E\bigcup F)=$ *NCS-cl* $(E)\bigcup$ *NCS-cl (F).*

Proof:

(i) *NCS-cl (E)* $=\bigcap\{\lambda:\lambda$ is *NCSCS* in X & $E\subseteq\lambda\}$.

Thus $E\subseteq$ *NCS-cl* (E).

(ii) *NCS-cl (F)* $=\bigcap\{\lambda:\lambda$ is a *NCSCS* in X & $F\subseteq\lambda\}\supseteq$ *NCS-cl (E)*

$=\bigcap\{\lambda:\lambda$ is *NCSCS* in X & $E\subseteq\lambda\}$.

Thus *NCS-cl* $(E)\subseteq$ *NCS-cl (F).*

(iii) *NCS-cl* $(E\bigcup F)=\bigcap\{\lambda:\lambda$ is *NCSCS* in X & $E\bigcup F\subseteq\lambda\}$

$=(\bigcap\{\lambda:\lambda$ is *NCSCS* in X & $E\subseteq\lambda\})\bigcup(\bigcap\{\lambda:\lambda$ is *NCSCS* in X & $F\subseteq\lambda\})$

$=$ *NCS-cl* $(E)\bigcup$ *NCS-cl* (F). Thus *NCS-cl* $(E\bigcup F)=$ *NCS-cl* $(E)\bigcup$ *NCS-cl* (F).

3.7. Proposition: Let (X,τ^{μ}) be any *NCSTS*. If E and F are any two *NCSs* in X. Then the neutrosophic crisp supra interior operator satisfies the following.

(i) *NCS-int* $(E)\subseteq E$

(ii) $E\subseteq F\Rightarrow$ *NCS-int* $(E)\subseteq$ *NCS-int* (F).

(iii) *NCS-int* $(E\bigcap F)=$ *NCS-int* $(E)\bigcap$ *NCS-int* (F).

(iv) *(NCS-cl* $(E))^C=$ *NCS -int* $(E)^C$.

(v) *(NCS-int (*E*))*^{C} = *NCS-cl*$(\mathrm{E})^C$.

Proof:

(i) *NCS-int (*E*)* = $\bigcup\{\lambda^* : \lambda^*$ is a *NCSOS* in X & $\lambda^* \subseteq \mathrm{E}\}$.

Thus *NCS-int (*E*)* $\subseteq \mathrm{E}$.

(ii) *NCS-int (*F*)* = $\bigcup\{\lambda^* : \lambda^*$ is a *NCSOS* in X & $\lambda^* \subseteq F\}$ $\supseteq \bigcup\{\lambda^* : \lambda^*$ is a *NCSOS* in X & $\lambda^* \subseteq \mathrm{E}\}$ $\supseteq$ *NCS-int (* E*)*. Thus *NCS-int (*E*)* $\subseteq$ *NCS-int (*F*)*.

(iii) *NCS-int*$(\mathrm{E} \cap F)$ = $\bigcup\{\lambda^* : \lambda^*$ is a *NCSOS* in X & $\lambda^* \subseteq \mathrm{E} \cap F\}$

= $(\bigcup\{\lambda^* : \lambda^*$ is a *NCSOS* in X & $\lambda^* \subseteq \mathrm{E}\}) \cap (\bigcup\{\lambda^* : \lambda^*$ is a *NCSOS* in X & $\lambda^* \subseteq F\})$

= *NCS-int (*E*)* $\cap$ *NCS-int (*F*)*.

Thus *NCS-int* $(\mathrm{E} \cap F)$ = *NCS-int (*E*)* $\cap$ *NCS-int (F)*.

(iv) *NCS-cl (*E*)* = $\bigcap\{\lambda : \lambda$ is a *NCSCS* in X & $\mathrm{E} \subseteq \lambda\}$,

(*NCS-cl*$((\mathrm{E}))^C$ = $\bigcup\{\lambda^C : \lambda^C$ is a *NCSOS* in X & $\mathrm{E}^C \supseteq \lambda^C\})$ = *NCS-int (*E*)*^{C}.

Thus (*NCS-cl*$(\mathrm{E}))^C$ = *NCS-int (*E*)*^{C}.

(v) *NCS-int (*E*)* = $\bigcup\{\lambda^* : \lambda^*$ is a *NCSOS* in X & $\lambda^* \subseteq E\}$,

(*NCS-int (*E*))*^{C}= $\bigcap\{\lambda^{*C} : \lambda^{*C}$ is a *NCSCS* in X & $\lambda^{*C} \supseteq \mathrm{E}^C\}$

= *NCS-cl (*E*)*^{C}.

Thus (*NCS-int (*E*))*^{C} = *NCS-cl*$(\mathrm{E})^C$.

3.8. Proposition: Let (X, τ^μ) be any *NCSTS* and *E* is any *NCS* of X.

Then the following are holds.

(i) *NCS-cl (*E*)* = $\mathrm{E} \Leftrightarrow \mathrm{E}$ is *NCSCS.*

(ii) *NCS-int (*E*)* = $\mathrm{E} \Leftrightarrow \mathrm{E}$ is *NCSOS.*

(iii) *NCS-cl (*E*)* is the smallest *NCSCS* containing *E*.

(iv) *NCS-int (*E*)* is the largest *NCSOS* contained in E.

Proof: ***(i), (ii), (iii),*** and ***(iv)*** are obvious.

IV. NEUTROSOPHIC CRISP SUPRA NEIGHBOURHOOD

4.1. Definition: Let (X,τ^{μ}) be a neutrosophic crisp supra topological space and p_N be a neutrosophic crisp point *(NCP)* of X. A neutrosophic crisp set $\mathcal{N}^*$ of X is called neutrosophic crisp supra neighbourhood *(NCSNBD)* of p_N if there exists an open set $G \in \tau^{\mu}$ such that $p_N \in G \subseteq \mathcal{N}^*$.

Thus a *NCSNBD* of p_N is either a superset or equal to the open set containing p_N.

The family consisting of all the *NCSNBDs* of a *NCP* $p_N \in X$ is called the system of *NCSNBDs* of X and denoted by *S* τ^{μ} (p_N).

From the definition every *NCSOS* is a *NCSNBD* of each *NCP*. But a *NCSNBD* of a *NCP* need not be a *NCSOS*. Also every open set containing p_N is a neighbourhood of p_N.

The *NCSNBD* $\mathcal{N}^*$ of a *NCP* is open if and only if $\mathcal{N}^*$ is open.

4.2. Example: Let $X=\{\delta_1,\eta_2,\psi_3,\sigma_4\}$, $\tau^{\mu}=\{\varphi_N, X_N, L, M, N\}$, where $L=<\{\delta_1,\eta_2\},\varphi,\{\psi_3\}>$, $M=<\{\delta_1,\eta_2\},\varphi,\{\psi_3,\sigma_4\}>$, $N=<\{\eta_2\},\varphi,\{\delta_1,\psi_3\}>$.

Then (X,τ^{μ}) is a *NCSTS*.

Let $p_N=<\{\eta_2\},\varphi,\{\delta_1,\psi_3,\sigma_4\}>$ is *NCP* on X.

Clearly $p_N \in N$, so that the *NCS* $\mathcal{N}^*$ of X is superset or equal to N are *NCSNBDs* of p_N.

For the *NCP* $p_N=<\{\delta_1\},\varphi,\{\eta_2,\psi_3,\sigma_4\}>$ of X, $p_N \in M$ and $M \subseteq L$.

Here L is also *NCSNBD* of p_N and also L is open.

4.3. Definition: Let (X,τ^{μ}) be a *NCSTS* and *E* be a neutrosophic crisp set of X. A subset $\mathcal{N}^*$ of X is called neutrosophic crisp supra neighbourhood (*NCSNBD)* of *E* if there exists an open set $G \in \tau^{\mu}$ such that $E \subseteq G \subseteq \mathcal{N}^*$.

4.4. Example: Let $X=\{\delta_1,\eta_2,\psi_3,\sigma_4\}$, $\tau^{\mu}=\{\varphi_N, X_N, L, M, N\}$, where $L=<\{\psi_3\},\{\eta_2\},\{\delta_1,\sigma_4\}>$, $M=<\{\delta_1,\psi_3\},\{\eta_2\},\{\sigma_4\}>$, $N=<\{\delta_1,\psi_3\},\varphi,\{\eta_2,\sigma_4\}>$.

Then (X,τ^{μ}) is a *NCSTS*.

Let $E=<\{\psi_3\},\varphi,\{\delta_1,\eta_2,\sigma_4\}>$ be a *NCS* on X.

Then clearly $\mathcal{N}^*=<\{\psi_3\},\{\eta_2\},\{\delta_1\}>$ is a *NCSNBD* of *E* since $E \subseteq L \subseteq \mathcal{N}^*$.

Also $E \subseteq L \subseteq M$ so M is a *NCSNBD* of *E* also M is *NCSOS*.

Hence *NCSNBD* of *E* is either a superset or equal to the *NCSOS* containing *E*.

The *NCSNBD* of a *NCS* need not be a *NCSOS*.

4.5. Theorem: Let (X,τ^{μ}) be a *NCSTS* and p_N be a *NCP* in X. Then

(i) Every p_N has at least one *NCSNBD*.

(ii) Every *NCSNBD* of p_N contains p_N.

(iii) Every set containing the *NCSNBD* of p_N is a *NCSNBD* of p_N.

(iv) The union of two *NCSNBD* of p_N is a *NCSNBD* of p_N.

(v) If $\mathcal{N}^*$ is a *NCSNBD* of p_N then there exists a *NCSNBD B* of p_N which is a subset of $\mathcal{N}^*$ such that *B* is a *NCSNBD* of each of its *NCPs* belongs to *B*.

Proof: Let (X,τ^{μ}) be a *NCSTS* and $S\tau^{\mu}$ *(* p_N) be the collection of all *NCSNBDs* of a *NCP* p_N of X .

(i) Clearly X_N is a *NCSNBD* of each *NCP* p_N of X .

(ii) Let $\mathcal{N}^* \in S\tau^{\mu}$ *(* p_N), by the definition of *NCSNBD* $p_N \in G$.

(iii) Let $\mathcal{N}^* \in S\tau^{\mu}$ *(* p_N), then there is a open set $G \in \tau^{\mu}$ such that $p_N \in G \subseteq \mathcal{N}^*$.

Suppose $N \subseteq \mathcal{N}^*$ then $p_N \in G \subseteq N$ so *N* is also a *NCSNBD* of p_N .

(iv) Let $T, U \in S\tau^{\mu}$ *(* p_N) then there exists a open sets $G_1, G_2 \in \tau^{\mu}$ such that $p_N \in G_1 \subseteq T$ and $p_N \in G_2 \subseteq U$.

So $p_N \in G_1 \bigcup G_2$ and $G_1 \bigcup G_2 \subseteq T \bigcup U$ and $G_1 \bigcup G_2 \in \tau^{\mu}$.

Hence $T \bigcup U$ is also a *NCSNBD* of p_N .

(v) Suppose $\mathcal{N}^* \in S\tau^{\mu}$ *(* p_N), then $\exists\ B \in \tau^{\mu} \ni p_N \in B \subseteq \mathcal{N}^*$.

Since *B* is *NCSOS*, it is a *NCSNBD* of each *NCP* belongs to *B*.

V. LOCAL BASE AND BASE OF NEUTROSOPHIC CRISP SUPRA TOPOLOGICAL SPACES

5.1. Definition: Let (X,τ^{μ}) be a *NCSTS*. A non-empty collection $\mathcal{B}$ *(* p_N *)* of *NCSNBDs* of *NCP* p_N of X is called a local base for the *NCSNBD* of p_N if for every *NCSNBD* $\mathcal{N}^*$ of p_N there is a $\mathcal{B}^* \in \mathcal{B}$ *(* p_N *)* such that $\mathcal{B}^* \subseteq \mathcal{N}^*$. If $\mathcal{B}$ *(* p_N *)* is local base of p_N then the members of $\mathcal{B}$ *(* p_N *)* are called basic *NCSNBD* of p_N .

5.2. Example: Let $X=\{\delta_1,\eta_2,\psi_3,\sigma_4\}$, $\tau^{\mu}=\{\varphi_N, X_N, L, M, N\}$, where $L=<\{\delta_1,\eta_2\},\varphi,\{\psi_3\}>$, $M=<\{\delta_1,\eta_2\},\varphi,\{\psi_3,\sigma_4\}>$, $N=<\{\eta_2\},\varphi,\{\delta_1,\psi_3\}>$.

Then (X,τ^{μ}) is a *NCSTS*.

Let $p_N=<\{\delta_1\},\varphi,\{\eta_2,\psi_3,\sigma_4\}>$.

$\mathcal{B}$ *(* p_N *)* $=\{S\}$, where $S=<\{\delta_1,\eta_2\},\varphi,\{\psi_3\}>$.

Let $\mathcal{N}^*=<\{\delta_1,\eta_2\},\varphi,\varphi>$ is *NCSNBD* of p_N.

Here $S \subseteq \mathcal{N}^*$. Hence $\mathcal{B}$ *(* p_N *)* is local base for p_N.

5.3. Theorem: Let (X,τ^{μ}) be a *NCSTS* and let p_N be a *NCP* of $x \in X$ and $p_N \in \tau^{\mu}$ .Then the collection $\mathcal{B}$ *(* x *)* of all neutrosophic crisp supra open subsets of X containing x is local base at x .

Proof: Let $\mathcal{N}^*$ be a *NCSNBD* of *NCP* p_N of $x \in X$ .Then there exists a open set *G* such that $p_N \in G \subseteq \mathcal{N}^*$. Since *G* is open set in τ^{μ} containing x , $G \in \mathcal{B}$ *(* x *)*. This shows that $\mathcal{B}$ *(* x *)* is a local base at x .

5.4. Definition: Let (X,τ^{μ}) be a *NCSTS*. A non empty collection $\mathcal{B}$ of neutrosophic crisp sets of X is said to be base for τ^{μ} if $\mathcal{B} \subseteq \tau^{\mu}$ and every *NCSNBD* $\mathcal{N}^*$ of p_N , there exists $\mathcal{B}^* \in \mathcal{B}$ such that $p_N \in \mathcal{B}^* \subseteq \mathcal{N}^*$.

5.5. Example: Let $X=\{\delta_1,\eta_2,\psi_3,\sigma_4\}$, $\tau^{\mu}=\{\varphi_N, X_N, L, M, N\}$, where $L=<\{\psi_3\},\{\eta_2\},\{\delta_1,\sigma_4\}>$, $M=<\{\delta_1,\psi_3\},\{\eta_2\},\{\sigma_4\}>$, $N=<\{\delta_1,\psi_3\},\varphi,\{\eta_2,\sigma_4\}>$.

Then (X,τ^{μ}) is a *NCSTS.*

Let $\mathcal{B}=\{L,N\}\subseteq\tau^{\mu}$ is a base for τ^{μ}. Since $p_N=<\{\psi_3\},\varphi,\{\delta_1,\eta_2,\sigma_4\}>\in L\subseteq \mathcal{N}^*$,

$p_N=<\{\delta_1\},\varphi,\{\eta_2,\psi_3,\sigma_4\}>\in M\subseteq \mathcal{N}^*$. Where $\mathcal{N}^*=\{\mathcal{G}/\mathcal{G}\supseteq L\,\&\,M\}$.

5.6. Theorem: Let (X,τ^{μ}) be a *NCSTS*. A non-empty collection $\mathcal{B}$ of τ^{μ} is base for τ^{μ} iff every *NCSOS* in τ^{μ} can be expressed as the union of members of $\mathcal{B}$.

Proof: Let $\mathcal{B}$ be a base for τ^{μ} and let $G\in\tau^{\mu}$.

Since *G* is open in τ^{μ} hence by the definition of base for each $p_N\in G$ there is $\mathcal{B}^*\in\mathcal{B}$ and $\mathcal{B}^*\subseteq G\Rightarrow G=\bigcup\{\mathcal{B}^*/\mathcal{B}^*\in\mathcal{B}$ and $\mathcal{B}^*\subseteq G\}$.

Conversely, let $\mathcal{B}\subseteq\tau^{\mu}$ and let every *NCSOS G* be the union of members of $\mathcal{B}$.

We have to show that $\mathcal{B}$ is base for τ^{μ} we have $\mathcal{B}\subseteq\tau^{\mu}$ and there exists a *NCSOS* $G\in\tau^{\mu}$ but *G* is the union of members of $\mathcal{B}$ so $\mathcal{B}$ is base for τ^{μ}.

VI. CONCLUSION

In this paper we introduced closure and interior of *NCSTS*. Also we introduced *NCSNBD* of *NCP* and local base, base of *NCST* also we investigated some of its basic properties. Finally we have huge scope for further research and we have planned to work some more concepts in *NCST.*

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