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Analyzing Pharmaceutical Compounds Through Neutrosophic Over Soft Hyperconnected Spaces

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ABSTRACT

Correlation is crucial in the decision-making approach. The foundational concepts of neutrosophic sets and topological spaces within the context of a basic environment is given. It introduces and explores innovative concepts such as neutrosophic over soft semi-j open sets and neutrosophic over soft hyperconnected spaces. Through a numerical illustration, the manuscript demonstrates the application of these concepts to determine the most effective method for a novel pharmaceutical application using a neutrosophic over soft measure of correlation. The findings highlight the practical utility and potential of these new theoretical constructs in enhancing decision-making processes within the pharmaceutical industry.

Keywords: Neutrosophic Over Soft Topological Space, Neutrosophic Over Soft open set, Neutrosophic Over Soft Connected Space, Neutrosophic Over Soft Hyperconnected Space and Neutrosophic Over Soft Extremely Disconnected.

INTRODUCTION

Uncertainty influences many facets of daily life, from the randomness of rolling dice to the unpredictability of flipping a coin on an uneven surface. These scenarios illustrate the fundamental nature of uncertainty, prompting the development of mathematical frameworks to address such variability. In 1965, Zadeh[24] introduced fuzzy sets, marking a significant milestone in mathematical theory by presenting the concept of membership degrees to model uncertainty. Zadeh also laid the groundwork for possibility theory[25], broadening the scope of how uncertainties could be conceptualized and managed. Building upon Zadeh's contributions, Bellman *et al.,*[4] explored decision-making under uncertainty, further solidifying the practical implications of fuzzy logic.

By introducing intuitionistic fuzzy sets, Atanassov[2] provided a more comprehensive framework for representing uncertain information. These sets consider degrees of membership, non-membership, and hesitation, extending fuzzy set theory to capture uncertainty more effectively.

The introduction of neutrosophic sets

by Smarandache[20] represented another leap forward, introducing a novel approach to handling uncertainty that goes beyond traditional fuzzy and intuitionistic models. Neutrosophic sets allow for the representation of indeterminate, contradictory, and uncertain information, offering versatile applications across diverse fields.

Christianto[6] proposed various utilities for neutrosophic sets, highlighting their potential in modeling complex and ambiguous information scenarios. Meanwhile, Molodtsov[16] introduced soft sets in 1999, which provide a mechanism to handle uncertainties in a set-theoretic context. Maji *et al.,*[15] subsequently advanced soft set theory, demonstrating its effectiveness in practical applications.

The concept of neutrosophic soft sets, introduced by Broumi[5] in 2002, combines the flexibility of neutrosophic sets with the simplicity of soft sets, enhancing their applicability in decision-making and problem-solving.

Smarandache introduced Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset in the year 2016[20] Smarandache's innovative contributions continued with the introduction of plithogenic sets and logic in 2017[22], offering new insights into handling uncertainties involving contradictory or paradoxical information. This concept has since garnered significant attention and further exploration[23,9] RN Devi and Y Parthiban introduced a novel concept of Neutrosophic Pythagorean Plithogenic Hypersoft Set Approach to School Selection With TOPSIS Method stimulating research efforts into its theoretical underpinnings and practical implications[7,8,17,13,14,18].

A notable advancement in this field is the elucidation of Plithogenic Hypersoft Sets within a Fuzzy Neutrosophic Environment by Rayees *et al.,*[3], underscoring the continued evolution and integration of these theories to address complex real-world problems[1,11,12].

This manuscript clearly expain the basic definitions for neutrosophic set and topological space. By inovating a concept neutrosophic over soft semi-j open set and neutrosophic over soft hyperconnected space. An numerical illustration is given to determine the most effective one for a new pharmaceutical application using neutrosophic over soft measure of correlation.

Preliminaries

This section introduces the basic definitions of Neutrosophic Set (NS)[20], Neutrosophic Over Soft Topological Space, Neutrosophic Over Set (NOS)[21], and Neutrosophic Over Soft Set (N_s^o-set).

Definition 1 [8]An N_s^o-set is defined as a valued function from the set of parameters E on a non-empty set H. This is expressed as:

$J = (\lambda N_s^o), \varepsilon) = \{(e, \{m, \vartheta_J(m), ð_J(m), ð_J(m)\ \gamma_J(m): m \in H\}): e \in \varepsilon\}$

The set-valued function defining the N_s^o-set is given by:

$\lambda N_s^o): \varepsilon \rightarrow \rho(H)$

Where $\rho(H)$ represents the set of all N_s^o-set on H.

Definition 2[8]An N_s^o-set $\odot = \{e, \{m, 0, 0, \Omega: m \in H\}: e \in \varepsilon\}$ is referred to as a Null N_s^o-set, and $\circledast = \{e,\{m, \Omega, \Omega, 0: m \in H\}: e \in \varepsilon\}$ is referred to as a universal N_s^o-set.

Definition 3[8] Let τN_s^o) be a N_s^o topology in the N_s^o-set J, which is a collection of subsets of an non-empty set H. The pair (H, τN_s^o) is called an N_s^o topological space if it satify the following conditions:

(i) $\odot, \circledast \in \tau N_s^o$.
(ii) Any arbitrary collection of sets in τN_s^o has a union that is also contained in τN_s^o.
(iii) A finite intersection of sets in τN_s^o belongs to τN_s^o.

In this context, an element of τN_s^o is referred to as an N_s^o open set and compliment of a set τN_s^o is referred to as an N_s^o closed set.

Definition 4[8] The operators for the N_s^o topological interior and closure are defined as int N_s^o (R) and cl N_s^o (R), respectively for all $R \in (H, \tau N_s^o)$. $intN_s^o(R) = \bigcup \{N: N \subseteq H \text{ and } N \in \tau N_s^o\}$ and cl N_s^o (R) $\cap = \{O : H \subseteq O \text{ and } O \in \tau N_s^{o\wp}\}$.

Neutrosophic Over Soft j-Open Set and Neutrosophic Over Soft Hyperconnected Space

In this part an introduction for $N_s{}^o$ β open set, $N_s{}^o$ Connected Space, $N_s{}^o$ Hyperconnected Space and $N_s{}^o$ Extremely Disconnected. Additionally, some of its fundamental properties are examined.

Definition 5 An $N_s{}^o$-set J in (H,τ$N_s{}^o$). Then J is said to be $N_s{}^o$ β open set ($N_s{}^o$-β open set) of X if and only if J ⊆ cl $N_s{}^o$ (int $N_s{}^o$ (cl $N_s{}^o$ (J)))

Theorem 3.1 Let Jα, where α = 1, 2, 3... be a collection of $N_s{}^o$-β open set in (H,τ$N_s{}^o$). Then UJα is also $N_s{}^o$-β open set in (H, τ($N_s{}^o$).

Proof. Since Jα is a $N_s{}^o$-β open set in (H,τ($N_s{}^o$). Then Jα ⊆ cl $N_s{}^o$ (int $N_s{}^o$ (cl $N_s{}^o$) (Jα). UJα ⊆ U (cl $N_s{}^o$ (int $N_s{}^o$ (cl $N_s{}^o$) (J) ⊆ cl $N_s{}^o$ (int $N_s{}^o$ (cl $N_s{}^o$ (UJα). Hence UJα is also $N_s{}^o$-β open set in (H, τ $N_s{}^o$).

Theorem 3.2 Let Jα, where = 1, 2, 3… be a collection of $N_s{}^o$-β open set in (H,τ$N_s{}^o$). Then ∩Jα is also $N_s{}^o$-β open set in (H,τ$N_s{}^o$).

Proof. Since Jα is a $N_s{}^o$-β open set in (H, τ $N_s{}^o$. Then Jα ⊇ cl $N_s{}^o$ (int $N_s{}^o$(cl$N_s{}^o$ (Jα). ∩Jα ⊇ ∩ (cl$N_s{}^o$ (int$N_s{}^o$) (cl $N_s{}^o$) (J) cl $N_s{}^o$ (int$N_s{}^o$ (cl $N_s{}^o$ (∩Jα). Hence Jα is also $N_s{}^o$-β open set in (H,τ $N_s{}^o$).

Theorem 3.3 In the space (H,τ $N_s{}^o$), every $N_s{}^o$-β open set is a neutrosophic open set. Proof. The proof is obvious.

Theorem 3.4 Let J be a $N_s{}^o$-β open set in an $N_s{}^o$-topological space (H, τ $N_s{}^o$), and suppose J ⊆ W ⊆ cl $N_s{}^o$) (J). Then, in (H,τ $N_s{}^o$), Q is also a $N_s{}^o$-β open set.

Proof. As J is $N_s{}^o$-β open set in (H,τ $N_s{}^o$). Then J ⊆ cl $N_s{}^o$ (int $N_s{}^o$ (cl $N_s{}^o$) (J). cl $N_s{}^o$) (J) ⊆ cl $N_s{}^o$ (cl $N_s{}^o$ (int $N_s{}^o$ (cl $N_s{}^o$) (J)))). cl $N_s{}^o$) (J) ⊆ cl $N_s{}^o$ (int $N_s{}^o$ (cl$N_s{}^o$) (J). [∴ cl $N_s{}^o$) (cl $N_s{}^o$) (J) = cl $N_s{}^o$) (J)]. By hypothesis J W cl $N_s{}^o$) (J) then cl $N_s{}^o$) (W) ⊆ cl $N_s{}^o$ (int $N_s{}^o$ (cl $N_s{}^o$) (J).

Since J W ∵ cl $N_s{}^o$ (int $N_s{}^o$ (cl$N_s{}^o$) (J) ⊆ cl $N_s{}^o$ (int $N_s{}^o$ (cl$N^s{}_o$) (W) cl$N_s{}^o$ (W) ⊆ cl$N_s{}^o$ (int $N_s{}^o$ (cl$N_s{}^o$) (W). Hence Q is a $N_s{}^o$-β open set in (H,τ$N_s{}^o$).

Definition 6 A $N_s{}^o$ in (H,τ$N_s{}^o$) is said to be proper, if it is neither ⨀ nor ⊛.

Definition 7 A $N_s{}^o$-topological space said to be $N_s{}^o$-connected, if it has no proper $N_s{}^o$-clopen set. $N_s{}^o$-topological space is not a $N_s{}^o$-connected then it is disconnected.

Theorem 3.5 A $N_s{}^o$-topological space said to be $N_s{}^o$-connected if and only if it doesn't have any $N_s{}^o$-open sets J and W providing that ϑ_J (m) = γ_W (m), γ_J (m)= ϑ_W (m) and $ð_J$ (m) =$ð_W$ (m).

Proof. Suppose there exist $N_s{}^o$-open sets J and W providing that ϑ_J (m) = γ_W (m), γ_J (m) = ϑ_W (m) and $ð_J$ (m) = $ð_W$ (m)

Then J and W are $N_s{}^o$-clopen sets in (H,τ$N_s{}^o$). (H, τ$N_s{}^o$) is not $N_s{}^o$-connected. (H, τ$N_s{}^o$) is $N_s{}^o$-connected.

Conversely, assume that (H, τ$N_s{}^o$) is $N_s{}^o$-connected. Then it has a proper $N_s{}^o$-clopen sets J. $J^{\wp}$ is a $N_s{}^o$-open set in (H, τ$N_s{}^o$) say $J^{\wp}$ = W.

ϑ_J (m) = γ_W (m),

γ_J (m) = ϑ_W (m),

Ω-$ð_J$ (m) = Ω-$ð_W$ (m)

-$ð_J$ (m) = -$ð_W$ (m)

$ð_J$ (m) = $ð_W$ (m)

Theorem 3.6 A $N_s{}^o$-topological space said to be $N_s{}^o$-connected if and only if it doesn't have any $N_s{}^o$-open sets J and W providing that ϑ_J (m) = $\gamma_{W^{\wp}}$) (m), γ_J(m) = $\vartheta_{W^{\wp}}$ (m) and $ð_J$ (m) = $ð_{W^{\wp}}$(m).

Proof. Directly derived from Theorem 3.5, the proof follows.

Definition 8 An $N_s{}^o$-set J in (H,τ $N_s{}^o$) is called

(i) $N_s{}^o$ Dense($N_s{}^o$-Dense) if cl $N_s{}^o$ (J) = ⊛.
(ii) $N_s{}^o$ Nowhere Dense($N_s{}^o$-NDense) if int(cl $N_s{}^o$) (J)) = ⨀.

Definition 9 An $N_s{}^o$ hyperconnected space is defined as an $N_s{}^o$-topological space (H,τ $N_s{}^o$), in which every non empty $N_s{}^o$-open subset of (H,τ $N_s{}^o$) is $N_s{}^o$-dense in (H,τ N_{so}).

Example 1 Let $\varepsilon = \{e\}$ be a set of parameter on H, where $H = \{s_1, s_2\}$ with $\tau N_s^o = \{\odot, \circledast, P_1, P_2, P_3\}$.
$P_1 = \{(e,\{ s_1,1.2,0.4,0.3, s_2,1.3,0.1,0.2: s_1, s_2 \in H\}) : e \in \varepsilon\}$
$P_2 = \{(e,\{ s_1,1.1,0.2,0.1, s_2,1.2,0.2,0.4: s_1, s_2 \in H\}): e \in \varepsilon\}$
$P_3 = \{(e,\{ s_1,1.02, 0.14,0.3, s_2, 1.1, 0.41, 0.22: s_1, s_2 \in H\}):e \in \varepsilon\}$

Here every non empty N_s^o-open sets $\circledast$, P_1, P_2, P_3 are N_s^o-Dense in H that is
$cl\ N_s^o (P_1) = \circledast$
$cl\ N_s^o (P_2) = \circledast$
$cl\ N_s^o (P_3) = \circledast$
$cl\ N_s^o (\circledast) = \circledast$
$\therefore$ H is N_s^o hyperconnected space

Theorem 3.7 Let $(H, \tau N_s^o)$ be an N_s^o-topological space. Then the following properties are equivalent.

(i) $(H,\tau N_s^o)$ is N_s^o-hyperconnected.
(ii) In $(H, \tau N_s^o)$, the only N_s^o-open sets are $\odot$ and $\circledast$. Proof. (i) $\rightarrow$ (ii)

Let $(H,\tau N_s^o)$ is N_s^o-hyperconnected. If J is a N_s^o- open set, then by the definition $J = intN_s^o$ (cl $N_s^o(P)$).

$(int\ N_s^o\ (cl\ N_s^o(P)^{\wp} = (\circledast\text{-}int\ N_{so}\ (cl\ N_s^o(P)) = cl\ N_s^o)\ (\circledast\text{-}cl\ N_s^o\ (J)) = cl\ N_{so}\ (J^{\wp}) = J^{\wp} \neq \circledast$

Since $J^{\wp} \neq \odot$. This contradicts the assumption.

Therefore, the only N_s^o-open sets are $\odot$ and $\circledast$. (ii) $\rightarrow$ (i)

Let $\odot$ and $\circledast$ be the only N_s^o-open sets in $(H,\tau N_s^o)$.

Suppose $(H,\tau N_s^o)$ is not an N_s^o-hyperconnected space. Then there exist a non empty J is a N_s^o-open set such that $cl\ N_s^o\ (J) = \circledast$
$(clN_{so}\ (intN_s^o)\ (P) \neq \circledast$
Therefore, we have $(clN_s^o)\ (int\ N_s^o)\ (P) = \odot$
$cl\ N_s^o\ (P) = \odot$
$\therefore P \neq \odot$

This contradicts our assumption that $(H, \tau N_s^o)$ is not an N_s^o-hyperconnected space.

Therefore, $(H,\tau N_s^o)$ must be an N_s^o-hyperconnected space.

Theorem 3.8 An N_s^o-topological space $(H,\tau N_s^o)$ is an N_s^o-hyperconnected space if and only if every N_s^o subset is either N_s^o-Dense or N_s^o-NDense.

Proof. Let $(H,\tau N_s^o)$ is N_s^o-hyperconnected space and let J be any N_s^o subset then $J \subseteq \circledast$.

Assume J is not N_s^o-NDense. Then $int\ N_s^o)\ (\circledast\text{-}cl\ N_s^o\ (J) = \circledast\ \text{-}int\ N_s^o\ (cl\ N_s^o)\ (J) \neq \circledast$ Since $int\ N_s^o\ (cl\ N_s^o)\ (J)) \neq \odot\ clN_{so}\ (int\ N_s^o\ (clN_s^o)\ (J) = \circledast\ cl\ N_s^o\ (J) = \circledast$

Hence J is N_s^o-Dense.

Conversely, Let J be any non empty set in N_s^o open set. Then $J \subset int\ N_s^o\ (clN_s^o)\ (J))$
$\therefore$ J is not a N_s^o-NDense.
J is a N_s^o-Dense.

Definition 10 A N_s^o-topological space $(H,\tau N_s^o)$ is called as N_s^o extremely disconnected (N_s^o-extremely disconnected) if the N_s^o-closure of each N_s^o-open set is N_s^o-open in $(H,\tau N_s^o)$.

Theorem 3.9 Every N_s^o-hyperconnected space is an N_s^o-extremely disconnected, in an N_s^o-topological space $(H,\tau N_s^o)$.

Proof. Let us take $(H,\tau N_s^o)$ is not N_s^o-hyperconnected. be N_s^o-hyperconnected. Then for any N_s^o-open set P, $clN_s^o)\ (P) = \circledast$.

clN_s^o (P) is N_s^o-open. Therefore $(H, \tau N_s^o)$ is not N_s^o-hyperconnected. is N_s^o-extremely disconnected.

Remark 1 The following example illustrates that the converse of the above theorem does not necessarily hold true.

Example 2 Let $\varepsilon = \{e\}$ be a set of parameter on H, where $H = \{s\}$ with $\tau N_s^o = \{\odot, \circledast, P_1, P_2, P_3\}$.
$P_1 = \{(e,\{ s,1.4,0.7,0.2 :s\ H\}): e \in \varepsilon\}$
$P_1 = \{(e,\{ s,0.2,0.7,1.4 :s\ H\}): e \in \varepsilon\}$
$P1 = \{(e,\{ s,1.1,0.5,0.3 :s\ H\}):e \in \varepsilon\}$
$clN_s^o(P_1)\{(e,\{ s,1.4,0.7,0.2 :s\ H\}): e \in \varepsilon\}$
$cl\ N_s^o(P_2) = \{(e,\{ s,1.4, 0.7, 0.2:s\ H\}): e \in \varepsilon\}$
$clN_s^o\ (P_3) = \{(e,\{ s,1.4,0.7,0.2 :s\ H\}): e \in \varepsilon\}$
$clN_s^o\ (\circledast) = \circledast$

$\therefore$ (H,τN_s°) is N_s°-extremely disconnected. But (H, $\tau(N_s^{\circ})$ is not N_s°-hyperconnected space. Since clN_s° (P_1), cl N_s° (P_2) and clN_s° (P_3) are N_s°-open but not N_s°-dense.

Correlation Measure for Neutrosophic Over Soft Set

Definition 11[8] Let J = (JN_s°), ε) and W = (W N_s°), ε) be a N_s°-set over an non-empty set H, where they are defined as follows:

J = {(e, { m, ϑ_J (m), $ð_J$ (m), γ_J (m): m ∈ H}):e∈ ε}
W = {(e, { m,ϑ_W (m), $ð_W$ (m), γ_W (m): m H}): e ∈ ε}

The correlation coefficients $\aleph_s$ and $\ddot{Y}_s$ between J and W are defined as:

$$\varphi(\mathcal{J},\mathcal{W}) = \frac{\mathcal{K}(\mathcal{J},\mathcal{W})}{n(\sqrt{\mathcal{K}(\mathcal{J},\mathcal{J})\mathcal{K}(\mathcal{W},\mathcal{W})})} \quad (1)$$

$$\varphi^{*}(\mathcal{J},\mathcal{W}) = \frac{\mathcal{K}(\mathcal{J},\mathcal{W})}{n[min(\mathcal{K}(\mathcal{J},\mathcal{J}),\mathcal{K}(\mathcal{W},\mathcal{W}))]} \quad (2)$$

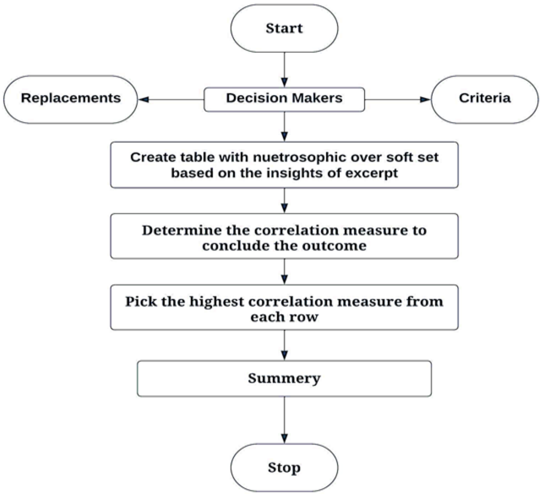
Where

$K(J,W) = \sum^{n}_{e=1}((\vartheta_J(m_e))^2.(\vartheta_W(m_e))^2 + (ð_J\ (m_e))^2.\ (ð_W\ (m_e))^2 + (\gamma_J\ (m_e))^2.(\gamma_W\ (m_e))^2)$

$K(J,J)=\sum^{n}_{e=1}\ ((\vartheta_J(m_e))^2.(\vartheta_J(m_e))^2 + (ð_J\ (m_e))^2.(ð_J\ (m_e))^2 + (\gamma_J\ (m_e))^2.(\gamma_J\ (m_e))^2)$

$K(W,W)=\sum^{n}_{e=1}\ ((\vartheta_W(m_e)^2.(\vartheta_W\ (m_e)^2 + (ð_W\ (m_e)^2.(ð_W\ (m_e)^2 +(\gamma_W\ (m_e)^2.(\gamma_W\ (m_e)^2)$

Flow Chart For Correlation Measure With To Solving N_s°-set



Numerical Illustration

Problem Statement

A research committee is evaluating three chemical compounds to determine the most effective one for a new pharmaceutical application. The evaluation is based on multiple criteria including Efficacy, Stability, and Safety. The compounds being evaluated are Ibuprofen, Paracetamol (Acetaminophen) and Aspirin (Acetylsalicylic acid). The committee needs to rank these compounds to decide which one to prioritize for further development.

Replacement and Criteria

We consider three compounds: Ibuprofen(I), Paracetamol(P) and Aspirin(A).

Where, molecular structure and formula for the compounds (Source: Adapted from[19])

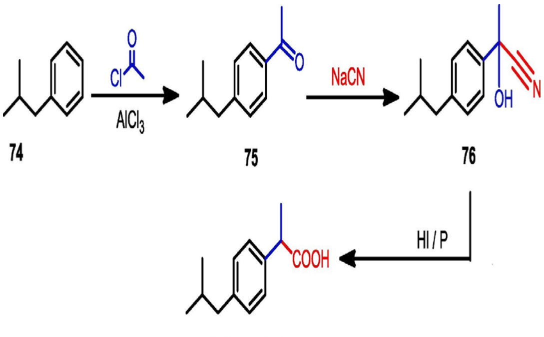


Fig. 1. Scheme of syntesis of ibuprofen

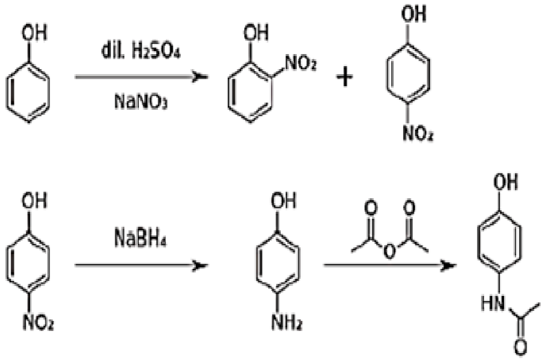


Fig. 2. Scheme of syntesis of Paracetamol

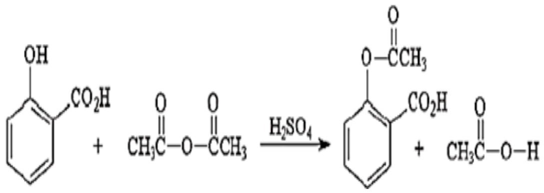


Fig. 3. Scheme of syntesis of aspirin

The required qualities are categorized under three main criteria: Efficacy, Stability, and Safety. The goal is to rank these compounds from best to worst based on their overall performance as Best Compound, Second Best Compound and Worst Compound.

Therefore, the Replacement sets are Compounds, Rank and the Criteria set is Efficacy, Stability, Safety.

Analized Data

Table 1: Correlation Between Required Compounds and Essential Qualities

X	Efficacy	Stability	Safety
I	(1.3,1.1,0.5)	(0.8,1.5,0.6)	(1.4,0.8,0.8)
P	(1.2,0.7,0.9)	(1.6,0.7,0.6)	(1.4,0.6,0.3)
A	(1.8,0.7,0.6)	(1.5,0.3,0.8)	(1.6,0.9,0.4)

Table 2: Correlation between Required Qualities and Rank

Z	Best Compound	Second Best Compound	Worst Compound
Efficacy	(0.9,1.5,0.4)	(0.5,1.3,0.6)	(1.5,0.5,0.6)
Stability	(1.1,0.5,0.3)	(1.5,0.6,0.7)	(1.4,0.3,0.7)
Safety	(1.3,0.7,0.8)	(1.1,0.7,0.4)	(0.9,0.8,0.6)

Table 3: $\aleph_s$ Correlation between Compounds and Rank

φ	Best Compound	Second Best Compound	Worst Compound
I	0.2529	0.2118	0.2161
P	0.2767	0.3032	0.2961
A	0.2385	0.2420	0.3155

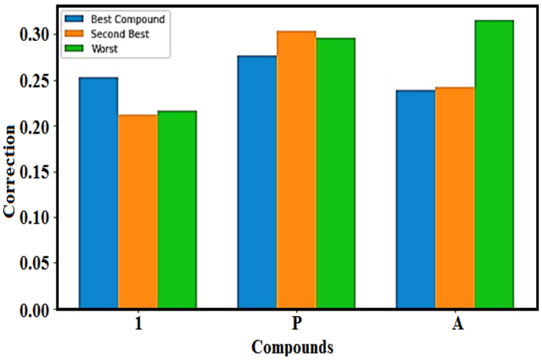


Fig. 4. $\aleph_s$ Correlation between Compounds and Rank

Table 4: $\ddot{Y}_s$ Correlation between Compounds and Rank

φ	Best Compound	Second Best Compound	Worst Compound
I	0.2947	0.2537	0.2547
P	0.3138	0.3535	0.3300
A	0.3527	0.3678	0.4719

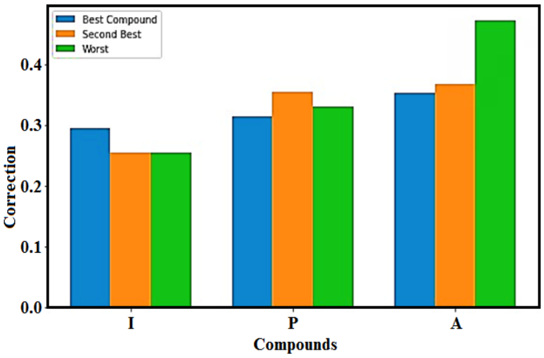


Fig 5: $\ddot{Y}_s$ Correlation between Compounds and Rank

Table 5: Summery

Compounds	Rank
I	Best Compound
P	Second Best Compound
A	Worst Compound

Thus the compund I got the most effective one for a new pharmaceutical application.Also, Compound P and A got second best and worst rank.

DISCUSSION

The results indicate that Ibuprofen is the most effective compound based on the criteria evaluated, followed by Paracetamol and Aspirin. This ranking aligns with existing literature on the efficacy and safety profiles of these compounds.

CONCLUTION

This paper gives a clear explaination for neutrosophic over soft semi-j open set and neutrosophic over soft hyperconnected space with its basic definitions theorem and suitable example. numerical illustration is given to understand the neutrosophic over soft set concept in a easyway. The application of $\aleph_s$ and $\ddot{Y}_s$ correlations provides a robust framework for evaluating pharmaceutical compounds. This method can be extended to other compounds and criteria, offering a versatile tool for pharmaceutical research.

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Conflict of interest

The authors declare no conflict of interest.

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