SOME THEOREMS ON T – ANTI-FUZZY IDEALS OF A ℓ –NEAR-RING

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Abstract**:** In this paper, we made an attempt to study the properties of $T-$anti- fuzzy ideal of a $\ell-$near-ring and family of $T-$anti-fuzzy ideals of $\ell-$near-ring, smallest $T-$ anti-fuzzy ideal of $\ell-$near-ring in *R*. We introduce the product of two $T-$anti-fuzzy ideals of a $\ell-$ near-ring in *R* and the product ΠA_i of $T-$anti-fuzzy ideals of a $\ell-$near-ring in *R*.

Keywords: Fuzzy subset, T - anti-fuzzy ideal, join of T - anti-fuzzy ideal, product of two T - fuzzy ideals, and ΠA_i of T - fuzzy ideal.

I. INTRODUCTION

The concept of fuzzy sets was initiated by Zadeh, L.A., in 1965. Liu. W., has studied fuzzy ideals of a ring and many researchers are engaged in extending the concepts. Abou-Zaid, S., introduced the notion of a fuzzy subnear-ring, and studied fuzzy ideals of a near-ring, and many followers discussed further properties of fuzzy ideals in near-rings. In Biswas, R., introduced the concept of anti-fuzzy subgroups of groups, and Kim, K.H., and Jun, J.B., studied the notion of anti-fuzzy *R*-subgroups of near-ring. In Kim, K.H., Jun, Y.B., and Yon, Y.H., introduced anti-fuzzy ideals in Near-Rings. In Hohle, U., introduced into fuzzy set theory and suggested that the T-norm be used for the intersection and union of fuzzy sets. Deena, P., Mohanraj, G., and Akram, M., have studied several properties of $T-$fuzzy ideals of rings and $T-$ fuzzy ideals of near-rings. We extended the results of Akram, M., to $\Gamma-$near-rings. In this paper we define, characterize and study the $T-$ anti-fuzzy right and left ideals. Prakashmanimaran,J., Chellappa, B., and Jeyakumar, M., introduced $T-$ anti-fuzzy right ideals of $\ell-$ring. We introduced $T-$ anti-fuzzy right ideals of $\ell-$ near-ring. We have shown that ring is regular if and only if union of any $T-$ anti-fuzzy right ideal with $T-$ anti-fuzzy left ideal is equal to its product. We discuss some of its properties. We have shown that product of two $T-$fuzzy ideals and ΠA_i of $T-$fuzzy ideal. $\ell-$ near-ring.

II. DEFINITIONS AND EXAMPLES

Definition: 1

A non-empty set R is called a near-ring with two binary operations "+" and " . " satisfying the following axioms:

(i) $(R, +)$ is a group

(ii) $(R, .)$ is a semigroup

(iii) $(x+y).z = x.z + y.z$, for all x, y, z in R

(i.e. Multiplicative is left distributive with respect to addition) We denote $x.y$ by xy.

Definition: 2

A non-empty set R is called lattice ordered near-ring or $\ell-$ near-ring if it has four binary operations "+" , " · " , $\vee, \wedge$ defined on it and satisfy the following

(i) $(R, +)$ is a group

(ii) $(R, \cdot)$ is a semigroup

(iii) $(R, \vee, \wedge)$ is a lattice

(iv) $x.(y+z) = x.y + x.z$, for all x, y, z in R

(v) $x+(y \vee z) = (x+y) \vee (x+z)$;
$x+(y \wedge z) = (x+y) \wedge (x+z)$
$(y \vee z)+x = (y+x) \vee (z+x)$;
$(y \wedge z)+x = (y+x) \wedge (z+x)$

(vi) $x \cdot (y \vee z) = (xy) \vee (xz)$;
$x \cdot (y \wedge z) = (xy) \wedge (xz)$
$(y \vee z) \cdot x = (yx) \vee (zx)$;
$(y \wedge z) \cdot x = (yx) \wedge (zx)$, for all x, y, z in R and $x \geq 0$

Example: 1

$(nZ, +, \cdot, \vee, \wedge)$ is a $\ell-$ near-ring, where Z is the set of all integers and $n \in Z$

Definition: 3

A mapping from a nonempty set X to $[0, 1]$ $\mu : X \to [0, 1]$ is called a fuzzy subset of X.

Definition: 4

A fuzzy subset μ of a lattice ordered ring (or $\ell-$ring) R is called an anti-fuzzy sub $\ell-$ring of R, if the following conditions are satisfied

(i) $\mu(x-y) \leq \max\{\mu(x), \mu(y)\}$

(ii) $\mu(xy) \leq \max\{\mu(x), \mu(y)\}$

(iii) $\mu(x \vee y) \leq \max\{\mu(x), \mu(y)\}$

(iv) $\mu(x \wedge y) \leq \max\{\mu(x), \mu(y)\}, \forall x, y \in R$

Example: 2

Consider the anti-fuzzy subset μ of the $\ell-$ ring $(Z, +, \cdot, \vee, \wedge)$

$$\mu(x) = \begin{cases} 0.4 & if \quad x \in \langle 3 \rangle \\ 0.8 & if \quad x \in Z - \langle 3 \rangle \end{cases}$$

Then μ is an anti-fuzzy $\ell-$sub ring.

Example: 3

Consider a fuzzy subset μ of the $\ell-$ ring $(Z, +, \cdot, \vee, \wedge)$

$$\mu(x) = \begin{cases} 0.3 & if \; x \in \langle 3 \rangle \\ 0.8 & if \; x \in Z - \langle 3 \rangle \end{cases}$$

Then μ is not an anti-fuzzy $\ell-$sub ring

For example, let $x = 3$ and $y = 7$,

then $x + y = 10$.

Here $\mu(x) = 0.8$ and $\mu(y) = 0.8$

$\therefore \max\{\mu_A(x), \mu_B(x)\} = \max\{0.8, 0.8\} = 0.8$

But $\mu_A(x+y) = 0.3$.

Hence $\mu_A(x+y) \leq \max\{\mu_A(x), \mu_A(y)\}$.

Thus μ is not an anti-fuzzy $\ell-$sub ring of R

Definition: 5

Let R be a $\ell-$ near-ring. A nonempty subset $(I, +)$ of $(R, +)$ is called

(i) a left ideal if $x.(y+i) - x.y \in I$, for all $x, y \in R$ and $i \in I$

(ii) a right ideal if $i.x \in I$, for all $x \in R$ and $i \in I$

(iii) an ideal if it is both a left ideal and a right ideal of R

Definition: 6

A fuzzy set μ in a near-ring R is said to be an anti-fuzzy ideal of R, if the following conditions are satisfied,

(i) $\mu(x-y) \leq \max(\mu(x), \mu(y))$

(ii) $\mu(y+x-y) \leq \mu(x)$

(iii) $\mu(xy) \leq \mu(y);\ \mu(xy) \leq \mu(x)$

(iv) $\mu((x+z)y - x\,y) \leq \mu(z), \forall x, y, z \in R$

Proposition: 1

If μ is an anti-fuzzy ideal of R, then $\mu(0) \leq \mu(x)$, for all $x \in R$

Definition: 7

A fuzzy subset μ of a $\ell-$near-ring R is called an anti-fuzzy ideal, if the following conditions are satisfied,

(i) $\mu(x-y) \leq \max(\mu(x), \mu(y))$

(ii) $\mu(y+x-y) \leq \mu(x)$

(iii) $\mu(xy) \leq \mu(y);\ \mu(xy) \leq \mu(x)$

(iv) $\mu((x+z)y - x\,y) \leq \mu(z)$

(v) $\mu(x \vee y) \leq \max(\mu(x), \mu(y))$

(vi) $\mu(x \wedge y) \leq \max(\mu(x), \mu(y))\ \forall x, y, z \in R$

Example: 4

Consider a near-ring $R = \{a, b, c, d\}$ with the following Cayley's tables:

+	a	b	c	d
a	a	b	c	d
b	b	a	d	c
c	c	d	b	a
d	d	c	a	b

.	a	b	c	d
a	a	a	a	a
b	a	a	a	a
c	a	a	a	a
d	a	a	b	b

We define an anti-fuzzy subset $\mu : R \to [0,1]$ by $\mu(a) < \mu(b) < \mu(d) = \mu(c)$

Then μ is an anti-fuzzy right (resp. left) ideal of R.

Definition: 8

A mapping $T : [0, 1] \times [0, 1] \to [0, 1]$ is called a triangular norm [$t-$norm] if and only if it satisfies the following conditions:

(i). $T(x, 1) = T(1, x) = x$, for all $x \in [0, 1]$

(ii). $T(x, y) = T(y, x)$, for all $x, y \in [0, 1]$.

(iii). $T(x, T(y, z)) = T(T(x, y), z)$

(iv). $T(x, y) \leq T(x, z)$, whenever $y \leq z$

Proposition: 2

The *minimum* $T-$norm ($\min T-$norm) is defined by $T(a, b) = \min\{a, b\}$

Definition: 9

An anti-fuzzy subset μ of a ring R is called $T-$anti-fuzzy right (resp. left) ideal if

(i) $\mu(x-y) \leq T(\mu(x), \mu(y))$

(ii) $\mu(xy) \leq (\mu(x))$ (resp. left $\mu(xy) \leq (\mu(y))$), for all x, y in R

Definition: 10
A fuzzy subset μ of a ring R is called $T-$anti-fuzzy ideal if it is satisfied both right and left ideals.

Proposition: 3
Every anti-fuzzy right ideal of a ring R is an $T-$anti-fuzzy right ideal.

Definition: 11
A fuzzy subset μ of a $\ell-$ring R is called an $T-$anti-fuzzy ideal, if the following conditions are satisfied,

(i) $\mu(x-y) \le T(\mu(x), \mu(y))$

(ii) $\mu(xy) \le \mu(x); \ \mu(xy) \le \mu(y)$

(iii) $\mu(x\vee y) \le T(\mu(x), \mu(y))$

(iv) $\mu(x\wedge y) \le T(\mu(x), \mu(y))$, for all $x, y\in R$

Definition: 12
A fuzzy subset μ of a near-ring R is called an $T-$anti-fuzzy ideal, if the following conditions are satisfied,

(i) $\mu(x-y) \le T(\mu(x), \mu(y))$

(ii) $\mu(y+x-y) \le (\mu(x))$

(iii) $\mu(xy) \le \mu(y); \ \mu(xy) \le \mu(x)$

(iv) $\mu((x+z)y-x\,y) \le (\mu(z))$, $\forall x,y,z\in R$

Proposition: 4
Every $T-$ fuzzy ideal of a near-ring R is a $T-$ fuzzy subnear-ring of R. Converse of Proposition 1 may not be true in general as seen in the following example.

Example: 5
From example: 4
Let $T:[0,1]\times[0,1]\to[0,1]$ be a function defined by $T(x,y)=\max(x+y-1,\,0)$, which is a $t-$norm for all $x,\ y\in[0,1]$. By routine calculations, it is easy to check that μ is a $T-$anti-fuzzy subnear-ring of R .It is clear that μ is also left $T-$anti-fuzzy ideal of R
But μ is not $T-$anti-fuzzy right ideal of R, since $\mu((c+d)d-cd)=\mu(d)<\ \mu(b)$

Definition: 13
A fuzzy subset μ of a $\ell-$near-ring R is called an $T-$anti-fuzzy ideal, if the following conditions are satisfied,

(i) $\mu(x-y) \le T(\mu(x), \mu(y))$

(ii) $\mu(y+x-y) \le (\mu(x))$

(iii) $\mu(xy) \le \mu(y); \ \mu(xy) \le \mu(x)$

(iv) $\mu((x+z)y-x\,y) \le (\mu(z))$

(v) $\mu(x\vee y) \le T(\mu(x), \mu(y))$

(vi) $\mu(x\wedge y) \le T(\mu(x), \mu(y))$, $\forall x,y,z\in R$

Example: 6
Now $(R=\{a, b, c\}, +, \cdot, \vee, \wedge)$ is a $\ell-$near-ring.
Consider an anti-fuzzy subset μ of the $\ell-$ring R

$$\mu(x)=\begin{cases}0.2 & if\ \ x=a\\ 0.5 & if\ \ x=b\\ 0.8 & if\ \ x=c\end{cases}$$

Then μ is an $T-$anti-fuzzy ideal of $\ell-$near-ring R

Definition: 14
Let μ and λ be $T-$anti-fuzzy ideals of a $\ell-$near-ring R. Then the direct product of $T-$anti-fuzzy ideal is defined by $(\mu\times\lambda)(x,y)=T(\mu(x),\lambda(y))$, for all x,y in R

III.THEOREMS

Theorem: 1
Every fuzzy ideal of a $\ell-$ near-ring R is an $T-$anti-fuzzy ideal in $\ell-$near-ring R.
Proof:
Let μ be a fuzzy right ideal of R. Then

(i) $\mu(x-y) \le T(\mu(x), \mu(y))$, $\forall x,y\in R$

(ii) $\mu(y+x-y) \le \mu(x)$, $\forall x,y\in R$ R

(iii) $\mu(xy) \le \mu(y)$, $\forall x,y\in R$

(iv) $\mu((x+z)y-x\,y) \le \mu(z)$, $\forall x,y,z\in R$

(v) $\mu(x\vee y) \le T(\mu(x), \mu(y))$, $\forall x,y\in R$

(vi) $\mu(x\wedge y) \le T(\mu(x), \mu(y))$, $\forall x,y\in R$

Hence μ is an $T-$anti-fuzzy ideal in $\ell-$near-ring R

Theorem: 2
If μ and λ are any two $T-$ anti-fuzzy ideal of $\ell-$near-rings R_1 and R_2 then the product of $\mu\times\lambda$ is also $T-$anti-fuzzy ideal of $\ell-$near-ring $R_1\times R_2$.

Proof:
Given μ and λ are any two $T-$anti-fuzzy ideal of $\ell-$near-rings R_1 and R_2 respectively.
Let $x,y,z\in R$

(i).
$$\begin{aligned}(\mu\times\lambda)(x-y) &= T\,(\mu(x-y)\,,\lambda(x-y))\\ &\le T\,(T(\mu(x), \mu(y)), T(\lambda(x), \lambda(y)))\\ &= T\,(T(T(\mu(x), \mu(y)), \lambda(x)), \lambda(y))\\ &= T(T(T((\mu\times\lambda)(x)), \mu(y)), \lambda(y))\\ &= T\,(T((\mu\times\lambda)(x)), T((\mu\times\lambda)(y)))\end{aligned}$$

$= T\left((\mu\times\lambda)(x),\ (\mu\times\lambda)(y)\right)$

$\therefore (\mu\times\lambda)(x-y) \le T\left((\mu\times\lambda)(x),\ (\mu\times\lambda)(y)\right)$,

$\forall x, y\in R$

(ii). Since $\mu(y+x-y) \le \mu(x)$ and

$\lambda(y+x-y) \le \lambda(x)$

$(\mu\times\lambda)(y+x-y)$

$= T\left(\mu(y+x-y),\ \lambda(y+x-y)\right)$

$\le T\left(\mu(x),\ \lambda(x)\right)$

$= (\mu\times\lambda)(x)$

$\therefore (\mu\times\lambda)(y+x-y) \le (\mu\times\lambda)(x),\ \forall x, y\in R$

(iii). Since $\mu(xy) \le \mu(x)$ and $\lambda(xy) \le \lambda(x)$

$(\mu\times\lambda)(xy) \le T\left(\mu(xy),\ \lambda(xy)\right)$

$\le T\left(\mu(x),\ \lambda(x)\right) = (\mu\times\lambda)(x)$

$\therefore (\mu\times\lambda)(xy) \le (\mu\times\lambda)(x),\ \forall x, y\in R$

(iv) Since $\mu((x+z)y-xy) \le \mu(z)$ and

$\lambda((x+z)y-xy) \ge \lambda(z)$

$(\mu\times\lambda)((x+z)y-xy)$

$= T\left(\mu((x+z)y-xy),\ \lambda((x+z)y-xy)\right)$

$\le T\left(\mu(z),\ \lambda(z)\right)$

$\le (\mu\times\lambda)(z)$

$\therefore (\mu\times\lambda)((x+z)y-xy) \le (\mu\times\lambda)(z), \forall x, y, z\in R$

(v). $(\mu\times\lambda)(x\vee y) = T\left(\mu(x\vee y),\ \lambda(x\vee y)\right)$

$\le T\left(T(\mu(x),\ \mu(y)),\ T(\lambda(x),\ \lambda(y))\right)$

$= T\left(T\left(T(\mu(x),\ \mu(y)),\ \lambda(x)\right),\ \lambda(y)\right)$

$= T\left(T\left(T((\mu\times\lambda)(x)),\ \mu(y)\right),\ \lambda(y)\right)$

$= T\left(T((\mu\times\lambda)(x)),\ T((\mu\times\lambda)(y))\right)$

$= T\left((\mu\times\lambda)(x),\ (\mu\times\lambda)(y)\right)$

$\therefore (\mu\times\lambda)(x\vee y) \le T\left((\mu\times\lambda)(x),\ (\mu\times\lambda)(y)\right)$,

$\forall x, y\in R$

(vi). $(\mu\times\lambda)(x\wedge y) = T\left(\mu(x\wedge y),\ \lambda(x\wedge y)\right)$

$\le T\left(T(\mu(x),\ \mu(y)),\ T(\lambda(x),\ \lambda(y))\right)$

$= T\left(T\left(T(\mu(x),\ \mu(y)),\ \lambda(x)\right),\ \lambda(y)\right)$

$= T\left(T\left(T((\mu\times\lambda)(x)),\ \mu(y)\right),\ \lambda(y)\right)$

$= T\left(T((\mu\times\lambda)(x)),\ T((\mu\times\lambda)(y))\right)$

$= T\left((\mu\times\lambda)(x),\ (\mu\times\lambda)(y)\right)$

$\therefore (\mu\times\lambda)(x\wedge y) \le T\left((\mu\times\lambda)(x),\ (\mu\times\lambda)(y)\right)$,

$\forall x, y\in R$

Thus $(\mu\times\lambda)$ is an $T-$ anti-fuzzy right ideal of $\ell-$near-ring $R_1\times R_2$.

Theorem: 3

If μ_i are $T-$anti-fuzzy ideal of $\ell-$near-rings R_i, then $\Pi\,\mu_i$ is $T-$ anti-fuzzy ideal of $\ell-$ near-ring ΠR_i

Proof:

If μ_i are $T-$anti-fuzzy ideal of $\ell-$near-rings R_i,

Let $x, y, z\in R$ and

Let $\mu_i \in R_i$, $i = 1, 2, 3, \ldots, n$

Let $\mu_1\times\mu_2\times\ldots..\times\mu_n$ in $R_1\times R_2\times\ldots..\times R_n$

Let $x = (x_1, x_2, \ldots, x_n)$ and $y = (y_1, y_2, \ldots, y_n)\in R_i$

Let $R = \prod_{i=1}^{n} R_i$

(i). $(\mu_1\times\mu_2\times\ldots..\times\mu_n)(x-y)$

$= T\left(\mu_1(x-y),\ \mu_2(x-y), \ldots.., \mu_n(x-y)\right)$

$\le T\left(T(\mu_1(x),\ \mu_1(y)), \ldots, T(\mu_n(x),\ \mu_n(y))\right)$

$= T\left(T((\mu_1\times\ldots\times\mu_n)(x)), T((\mu_1\times\ldots\times\mu_n)(y))\right)$

$= T\left((\mu_1\times\ldots\times\mu_n)(x),\ (\mu_1\times\ldots\times\mu_n)(y)\right)$

$\therefore (\mu_1\times\ldots\times\mu_n)(x-y)$

$\le T\left((\mu_1\times\ldots\times\mu_n)(x),\ (\mu_1\times\ldots\times\mu_n)(y)\right)\ \forall x, y\in R$

(ii). Since $\mu_i(y+x-y) \le \mu_i(x)$

$(\mu_1\times\mu_2\times\ldots..\times\mu_n)(y+x-y)$

$= T\left(\mu_1(y_1+x_1-y_1), \ldots.\mu_n(y_n+x_n-y_n)\right)$

$\ge T\left(\mu_1(x),\ \mu_2(x)\ldots.\mu_n(x)\right)$

$= (\mu_1\times\mu_2\times\ldots..\times\mu_n)(x)$

$\therefore (\mu_1\times\ldots.\times\mu_n)(y+x-y) \le (\mu_1\times\ldots..\times\mu_n)(x)$,

$\forall x, y\in R$

(iii). Since $\mu_i(xy) \le \mu_i(x)$ and $\lambda_i(xy) \le \lambda_i(x)$

$(\mu_1\times\mu_2\times\ldots\times\mu_n)(xy) \le T\left(\mu_1(xy),\ \mu_2(xy)\ldots\mu_n(xy)\right)$

$\le T\left(\mu_1(x),\ \mu_2(x)\ldots..\ \mu_n(x)\right)$

$\le (\mu_1\times\mu_2\times\ldots..\times\mu_n)(x)$

$\therefore (\mu_1\times\mu_2\times\ldots\times\mu_n)(xy) \le (\mu_1\times\mu_2\times\ldots\times\mu_n)(x)$,

$\forall x, y\in R$

(iv). Since $\mu_i((x+z)y-x\,y) \le \mu_i(z)$

$(\mu_1\times\mu_2\times\ldots..\times\mu_n)((x+z)y-x\,y)$

$= T\left(\mu_1((x_1+z_1)y_1-x_1y_1), \ldots\ \mu_n((x_n+z_n)y_n-x_ny_n)\right)$

$= T\left(\mu_1(x_1y_1+z_1y_1-x_1y_1), \ldots\ \mu_n(x_ny_n+z_ny_n-x_ny_n)\right)$

$= T\left(\mu_1(z_1y_1),\ \mu_2(z_2y_2)\ldots.\ \mu_n(z_ny_n)\right)$

$\leq\ T\left(\mu_1(z_1),\ \mu_2(z_2),....\ \mu_n(z_n)\right)$

$\leq\ (\mu_1\times\mu_2\times .....\times\mu_n)(z)$

$\therefore\ (\mu_1\times...\times\mu_n)((x+z)y-x\ y)\leq(\mu_1\times...\times\mu_n)(z)$, $\forall x, y\in R$

(v) $((\mu_1\times...\times\mu_n))(x\vee y)=T(\mu_1(x\vee),..,\mu_n(x\vee y))$

$\leq T\left(T(\mu_1(x),\ \mu_1(y)),...,\ T(\mu_n(x),\ \mu_n(y))\right)$

$=T\left(T(((\mu_1\times...\times\mu_n))(x)),\ T(((\mu_1\times...\times\mu_n))(y))\right)$

$=\ T\ (((\mu_1\times...\times\mu_n))(x),\ ((\mu_1\times...\times\mu_n))(y))$

$\therefore\ (\mu_1\times\mu_2\times .....\times\mu_n)(x\vee y)$

$\leq T\ ((\mu_1\times...\times\mu_n)(x),\ (\mu_1\times....\times\mu_n)(y))\ \forall x, y\in R$

(vi) $(\mu_1\times...\times\mu_n)(x\wedge y)=T(\mu_1(x\wedge y)..,\mu_n(x\wedge y))$

$\leq T\left(T(\mu_1(x),\mu_1(y)),\ ..,T(\mu_n(x),\mu_n(y))\right)$

$=T\left(T((\mu_1\times...\times\mu_n)(x)),T((\mu_1\times...\times\mu_n)(y))\right)$

$=\ T((\mu_1\times...\times\mu_n)(x),\ (\mu_1\times...\times\mu_n)(y))$

$\therefore\ (\mu_1\times...\times\mu_n)(x\wedge y)$

$\leq T((\mu_1\times...\times\mu_n)(x),\ (\mu_1\times...\times\mu_n)(y)),\ \forall x, y\in R$

Thus $\mu_1\times\mu_2\times ...\times\mu_n$ is an $T-$anti-fuzzy ideal of $\ell-$ near-ring R_i.

Hence $\Pi\mu_i$ is an $T-$anti-fuzzy ideal of $\ell-$near-ring R_i

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