CERTAIN FILTERS IN TERNARY SEMIGROUPS

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Abstract: The notion of a ternary semigroup was introduced by Lehmer in 1932 .In this paper the concepts of ternary filter, ternary filter of a ternary semigroup T generated by A, principal ternary filter are introduced and studied. We generalize the results in using the concepts of 3- system and 3*- system. It is proved that (1) The nonempty intersection of two ternary filters of a ternary semigroup T is also a ternary filter and (2) The nonempty intersection of a family of ternary filters of a ternary semigroup T is also a ternary filter. It is proved that a nonempty subset F of a ternary semigroup T is a ternary filter if and only if T\F is a completely prime ideal of T or empty. It is also proved that if F is a ternary filter of a ternary semigroup T, then T\F is (i) a prime ideal, (ii) a completely semiprime ideal, (iii) a semiprime ideal of T or empty and finally (iv) a nonempty subset F of a commutative ternary semigroup T is a ternary filter if and only if T\F is a prime ideal of T or empty. Further it is proved that every ternary filter F of a ternary semigroup T is (1) a 3-system of T (2) a 3-system of T and (3) a 3*-system of T.

Key Words: Ternary semigroup, Ternary ideal, Principal ideal, Ternary filter, 3*-system and Principal ternary filter.

Introduction: The theory of ternary algebraic systems was introduced by LEHMER [7] in 1932, but earlier such structures was studied by KERNER [5] who give the idea of n-ary algebras. Ternary semigroups are universal algebras with one associative ternary operative. ANJANEYULU.A [1] initiated the study of ideals in semigroups. S.KAR and B.K.MAITY [4] initiated the study of some ideals of ternary semigroips. SIOSON. F.M [11] studied about ideal theory in ternary semigroups. SANTIAGO (1990) studied regular ternary semigroups. DIXIT and DEWAN (1995) studied quasi – ideals and bi-ideals in ternary semigroups.PETRICH. M. (1973) made a study on filters in general semigroups. LEE. S. K and LEE. S. S. [6], introduced the notion of a left (right) filter in a po-semigroup and gave a characterization of the left (right)-filter of S in term of the right (left) prime ideals. N. KEHAYOPULU [10], gave the characterization of the filter of S in terms of the prime ideals in ordered semigroups.

Preliminaries:

Definition 2.1: Let T be a non-empty set. Then T is said to be a *Ternary semigroup* if there exist a mapping from T×T×T to T which maps (x_1, x_2, x_3) $\to [x_1x_2x_3]$ satisfying the condition : $[[x_1x_2x_3]x_4x_5] = [x_1[x_2x_3x_4]x_5] = [x_1x_2[x_3x_4x_5]]$ $\forall\ x_i \in$ T, $1 \le i \le 5$.

Note 2.2: Let T be a ternary semigroup. If A, B and C are three subsets of T , we shall denote the set ABC = $\{abc : a \in A, b \in B, c \in C\}$.

Note 2.3: Any semigroup can be reduced to a ternary semigroup.

Definition 2.4: A ternary semigroup T is said to be *commutative* provided *abc* = *bca* = *cab* = *bac* = *cba* = *acb* for all *a,b,c*∈ T.

Definition 2.5: A ternary semigroup T is said to be *quasi commutative* provided for each *a, b, c*∈ T, there exists a odd natural number *n* such that *abc* = $b^n ac$ = *bca* = $c^n ba$ = *cab* = $a^n cb$.

Definition 2.6: (IAMPAN. A [3]) : Let T be ternary semigroup. A non empty subset 'S' is said to be a *ternary subsemigroup* of T if abc ∈ S for all *a,b,c*∈ S.

Note 2.7: A non empty subset S of a ternary semigroup T is a ternary subsemigroup if and only if SSS ⊆ S.

Definition 2.8: (SARITHA DEWAN [14]): A nonempty subset A of a ternary semigroup T is said to be *left* (*lateral, right*) *ternary ideal* or *left* (*lateral, right*) *ideal*of T if *b, c*∈ T, *a*∈ A implies *bca*∈ A (*bac* ∈ A, *abc*∈ A) .

Note 2.9: A nonempty subset A of a ternary semigroup T is a left (lateral, right) ideal of T if and only if TTA ⊆ A (TAT ⊆ A, ATT ⊆ A).

Definition 2.10: A nonempty subset A of a ternary semigroup T is *ternary ideal* or *ideal*of T if $b, c \in T$, $a \in A$ implies $bca \in A$, $bac \in A$, $abc \in A$.

Definition 2.11: An ideal A of a ternary semigroup T is said to be a *principal ideal generated by a* provided A is an ideal generated by $\{a\}$ for some $a \in T$. It is denoted by J (a) (or) $<a>$.

Definition 2.12: An ideal A of a ternary semigroup T is said to be a *completely prime ideal* of T provided x, y, z $\in$ T and xyz $\in$A implies either x$\in$ A or y $\in$A or z $\in$A.

Example: 2.13: In the commutative ternary semigroup Z^- of all negative integers, the ideal P= {3k: k $\in Z^-$} is a completely prime ideal. For $x; y; z \in Z^-$, $xyz \in P \Leftrightarrow xyz$ is divisible by 3 $\Leftrightarrow x$ is divisible by 3 or y is divisible by 3 or z is divisible by 3 $\Leftrightarrow x = 3k_1$ or $y = 3k_2$ or z = $3k_3$ for $k_1 ; k_2 ; k_3 \in Z \Leftrightarrow x \in P$ *or* $y \in P$ *or* $z \in P$.

Example 2.14: In example 2.13, P is a completely prime ideal. But the ideal Q = { 30k : k $\in Z^-$} is not a prime ideal of Z^-, since (-2) (-3) (-5) = -30 $\in$Q but (-2) $\notin$ Q, (-3) $\notin$ Q and (-5) $\notin$ Q.

Definition2.15: (Muhammad Shabir And Mehar Bano [10]) : An ideal A of a ternary semigroup T is said to be a *prime ideal* of T provided X,Y,Z are ideals of T and XYZ $\subseteq$ A $\Rightarrow$ X $\subseteq$A or Y $\subseteq$A or Z $\subseteq$A.

Theorem 2.16: Every completely prime ideal of a ternary semigroup T is a prime ideal of T.

Proof: Suppose that A is a completely prime ideal of a ternary semigroup T. Let $a,b,c \in$ T and $<a><b><c> \subseteq$ A. Then $abc \in$ A. Since A is a completely prime, either $a \in$A or $b \in$A or $c \in$A. Therefore A is a prime ideal of T.

Theorem 2.17: Let T be a commutative ternary semigroup . An ideal P of T is a prime ideal if and only if P is a completely prime ideal.

Definition 2.18: A nonempty subset A of a ternary semigroup T is said to be a 3-systemprovided for any a, b, $c \in$A implies that $T^1T^1aT^1T^1bT^1T^1c\ T^1T^1 \cap A \neq \emptyset$.

Theorem 2.19: An ideal A of a ternary semigroup T is a prime ideal of T if and only if T\A is an 3-system of T or empty.

Proof : Suppose that A is a prime ideal of a ternary semigroup T and T\A $\neq \emptyset$.

Let a, b ,$c \in$T\A . Then $a \notin$A , $b \notin$A and $c \notin$A.

Suppose if possible $T^1T^1aT^1T^1bT^1T^1c\ T^1T^1 \cap$ T\A = $\emptyset$.

$T^1T^1aT^1T^1bT^1T^1c\ T^1T^1 \cap$ T\A = $\emptyset \Rightarrow T^1T^1aT^1T^1bT^1T^1c\ T^1T^1 \subseteq$ A.

Since A is prime, either $a \in$A or $b \in$A or $c \in$A.

It is a contradiction. Therefore $T^1T^1aT^1T^1bT^1T^1c\ T^1T^1 \cap$ T\A $\neq \emptyset$.

Hence T\A is a 3-system.

Conversely suppose that T\A is either a 3-system of T or T\A = $\emptyset$.

If T\A = $\emptyset$, then T = A and hence A is a prime ideal of T.

Assume that T\A is a 3-system of T. Let a, b, $c \in$T and $<a>< b><c> \subseteq$ A.

Suppose if possible $a \notin$A, $b \notin$A and $c \notin$A. Then a, b, $c \in$T\A. Sine T\A is a 3-system,

$\Rightarrow T^1T^1aT^1T^1bT^1T^1c\ T^1T^1 \cap$ T\A $\neq \emptyset \Rightarrow T^1T^1aT^1T^1bT^1T^1c\ T^1T^1 \nsubseteq$A

$\Rightarrow <a><b><c> \nsubseteq$A. It is a contradiction.

Therefore $a \in$A or $b \in$A or $c \in$A. Hence A is a prime ideal of T.

Definition 2.20: An ideal A of a ternary semigroup T is said to be a *completely semiprime ideal* provided $x \in$T, $x^n \in$A for some odd natural number n>1 implies $x \in$A.

Example 2.21: In commutative ternary semigroup Z^- of all negative integers, the ideal Q = {$6k$: $k \in Z^-$} is a semiprime ideal. For $x \in Z^-$, $x^3 \in$ Q $\Leftrightarrow x^3$ is divisible by 6 $\Leftrightarrow x$ is divisible by 6 $\Leftrightarrow x = 6k_1$ for $k_1 \in Z^- \Leftrightarrow x \in$ Q.

Corollary 2.22: If an ideal A of a ternary semigroup T is completely semiprime then x, y, $z \in$ T, $xyz \in$ A $\Rightarrow <x><y><z > \subseteq$ A.

Theorem 2.23: Every completely prime ideal of a ternary semigroup T is a completely semiprime ideal of T.

Proof: Let A be a completely prime ideal of a ternary semigroup T. Suppose that $x \in$T and $x^3 \in$A. Since A is a completely prime ideal of T, $x \in$A.

Therefore A is a completely semiprime ideal.

Theorem 2.24: Let A be a prime ideal of a ternary semigroup T. If A is completely semiprime ideal of T then A is completely prime.

Proof: Let x, y, $z \in$ T and $xyz \in$ A. Since A is completely semiprime, by corollary 2.22, $xyz \in$ A $\Rightarrow <x><y><z> \subseteq$ A $\Rightarrow x \in$ A or $y \in$ A or $z \in$ A and hence A is completely prime.

Theorem 2.25: The nonempty intersection of any family of a completely prime ideal of a ternary semigroup T is a completely semiprime ideal of T.

Definition 2.26: Let T be a ternary semigroup. A non-empty subset A of T is said to be a d-systemof T if $a \in A \Rightarrow a^3 \in A$.

Theorem 2.27: An ideal A of a ternary semigroup T is completely semiprime if and only if T\A is a *d*-system of T or empty.

Proof: Suppose that A is a completely semiprime ideal of T and $T \backslash A \neq \emptyset$.

Let $a \in T\backslash A$. Then $a \notin A$. Suppose if possible $a^3 \notin T\backslash A$.

Then $a^3 \in A$. Since A is a completely semiprime ideal then $a \in A$.

It is a contradiction. Therefore $a^3 \in T\backslash A$ and hence T\A is a *d*-system .

Conversely suppose that T\A is a *d*-system of T or T\A is empty.

If T\A is empty then T = A and hence A is completely semiprime.

Assume that T\A is a *d*-system of T. Let $a \in T$ and $a^3 \in A$.

Suppose if possible $a \notin A$. Then $a \in T\backslash A$.

Since T\A is a *d*-system, $a^3 \in T\backslash A$. It is a contradiction. Hence $a \in A$.

Thus A is a completely semiprime ideal of T.

Definition 2.28: An ideal A of a ternary semigroup T is said to be *semiprime ideal* provided X is an ideal of T and $X^n \subseteq A$ for some odd natural number *n*implies $X \subseteq A$.

Theorem 2.29: Every completely semiprime ideal of a ternary semigroup T is a semiprime ideal of T.

Proof: Suppose that A is a completely semiprime ideal of a ternary semigroup T.

Let $a \in T$ and $\langle a \rangle^n \subseteq A$ for some odd natural number *n*.

Now $aaa.....a$(n oddterms) $\in \langle a^n \rangle \subseteq \langle a \rangle^n \subseteq A \Rightarrow a^n \in A$ $\Rightarrow a \in A \Rightarrow \langle a \rangle \subseteq A$.

Therefore A is a semiprime ideal of T.

Definition2.30: A non-empty subset A of a ternary semigroup T is said to be a 3^*-*system* provided for any $a \in A$ implies that $T^1T^1aT^1T^1aT^1T^1aT^1T^1 \cap A \neq \emptyset$.

Theorem 2.31: Every 3-system in a ternary semigroup T is an 3^*-system.

Proof: Let A be 3-system of a ternary semigroup T. Let $a \in A$. Since A is 3-system, $a \in A$, $T^1T^1aT^1T^1aT^1T^1aT^1T^1 \cap A \neq \emptyset$. Therefore *A is* a$3^*$-system of T.

Theorem 2.32: An ideal Q of a ternary semigroup T is a semiprime ideal if and only if T\Q is a 3^*-systemof T (or) empty.

Proof: Suppose that A is a semiprime ideal of a ternary semigroup T and $T\backslash A \neq \emptyset$.

Let $a \in T\backslash A$. Then $a \notin A$.

Suppose if possible $T^1T^1aT^1T^1aT^1T^1aT^1T^1 \cap T\backslash A = \emptyset$.

$T^1T^1aT^1T^1aT^1T^1aT^1T^1 \cap T\backslash A = \emptyset \Rightarrow T^1T^1aT^1T^1aT^1T^1aT^1T^1 \subseteq A$.

Since A is semiprime, $a \in A$.

It is a contradiction. Therefore $T^1T^1aT^1T^1aT^1T^1aT^1T^1 \cap T\backslash A \neq \emptyset$.

Hence T\A is a 3^*-system.

Conversely suppose that T\A is either a 3^*-system or $T\backslash A = \emptyset$.

If $T\backslash A = \emptyset$ then T = A and hence A is a semiprime ideal.

Assume that T\A is a 3^*-system of T. Let $a \in T$ and $\langle a \rangle \subseteq A$.

Let $a \in T\backslash A$, T\A is a 3^*-system of T $\Rightarrow$ $T^1T^1aT^1T^1aT^1T^1aT^1T^1 \cap T\backslash A \neq \emptyset$.

Suppose if possible $a \notin A$. Then $a \in T\backslash A$. Since T\A is a 3-system.

Then $T^1T^1aT^1T^1aT^1T^1aT^1T^1 \subseteq T\backslash A$

$\Rightarrow T^1T^1aT^1T^1aT^1T^1aT^1T^1 \nsubseteq A \Rightarrow \langle a \rangle \nsubseteq A$.

It is a contradiction. Therefore $a \in A$. Hence A is a semiprime ideal of T.

Main Results In Ternary Filters:

Definition 3.1.1: A Ternary Subsemigroup F is said to be *ternary filter* of T if *a*, *b*, *c* ∈ T and abc ∈F implies *a*, *b*, *c* ∈ F .

Example 3.1.2: Let T = {*a*, *b*, *c*, *d* } with the ternary multiplication defined by

$$xyz = \begin{cases} b & \text{if } x = y = z = b \\ c & \text{if } x = y = z = c \\ d & \text{if } x = y = z = d \\ a & \text{otherwise} \end{cases}$$

Then T is a ternary semigroup and { *a*, *b*, *c*, *d* } , { *b*}, { *c* }, { *d* } are all filters of T.

Theorem 3.1.3: The nonempty intersection of two ternary filters of a ternary semigroup T is also a ternary semigroup of T.

Proof: Let A, B be two ternary filters of T.

Let *a*, *b*, *c* ∈ T and $abc \in A \cap B$.

$abc \in A \cap B \Rightarrow abc \in A$ and $abc \in B$.

a, *b*, *c*∈ T , $abc \in A$ and A is a ternary filter of T ⇒*a*, *b*, *c*∈ A.

a, *b*, *c*∈ T , *abc*∈ B and B is a ternary filter of T ⇒*a*, *b*, *c*∈ B.
a, *b*, *c*∈ A and *a*, *b*, *c*∈ B ⇒*a*, *b*, *c*∈ A∩B.
Therefore A∩B is a ternary filter of T.

Theorem 3.1.4: The nonempty intersection of a family of ternary filters of a ternary semigroup T is also a ternary filter of T.

Proof: Let $\{F_\alpha\}_{\alpha\in\Delta}$ be a family of ternary filters of T and let $F=\bigcap_{\alpha\in\Delta}F_\alpha$.

Let *a, b, c*∈T, *abc*∈ F. Now *abc*∈ F ⇒*abc*∈ $\bigcap_{\alpha\in\Delta}F_\alpha$ ⇒

$abc\in F_\alpha$ for each *α*∈ Δ.

$abc\in F_\alpha$, F_α is a ternary filter of T ⇒*a, b, c*∈ F_α.

⇒*a, b, c*∈ $\bigcap_{\alpha\in\Delta}F_\alpha$ ⇒*a, b, c*∈ F. Therefore F is a ternary filter of T.

Note3.1.5: In general, the union of two ternary filters is not a ternary filter.

Example3.1.6: As in the example 3.1.2, T is a ternary semigroup and {*b*},{*c*}, {*d* }, are ternary filters, but {*b*} ∪ {*c*} ∪ {d} is not a ternary filter of T, because *bcd* = *a* is not in {*b*} ∪ {*c*}∪ {*d* }.

Theorem 3.1.7: A nonempty subset F of a ternary semigroup T is a ternary filter if and only if T\F is a completely prime ideal of T or empty.

Proof: Assume that T\F ≠ ∅. Let *x, y, z*∈ T\F.
Suppose that *xyz*∉ T\F, then*xyz* ∈ F. Since F is ternary filter and hence *x, y, z*∈ F
It is a contradiction. Thus *xyz*∈ T\F, and so TT (T\F) TT ⊆ T\F
Therefore T\F is an ideal of T.
Now we shall prove that T\F is completely prime. Let *xyz*∈ T\F, for *x, y, z*∈ T
Suppose that *x*∉ T\F, *y* ∉ T\F and *z*∉ T\F .then *x*∈ F, *y* ∈ F and *z*∈ F.
Since F is a ternary subsemigroup of *T* , *xyz* ∈ F
It is a contradiction. Thus *x* ∈ T\F or *y* ∈ T\F or z∈ T\F.
Hence T\F is completely prime and hence T\F is completely prime ideal of T.
Conversely suppose that, T\F is completely prime ideal of T or empty.
If T\F is empty, Then F = T. Thus F is ternary filter of T.
Assume that T\F is completely prime ideal of T.
Suppose that for *x, y, z* ∈ F, *xyz* ∉ F .Then *xyz*∈ T\F , for *x, y, z* ∈ F.
Since T\F is completely prime, *x* ∈ T\F or *y* ∈ T\F or z∈ T\F.
It is contradiction. Thus *xyz*∈F and hence F is ternary subsemigroup of T.
Let *x, y, z*∈ T and hence *xyz*∈ F. If *x, y, z* ∉ F. Then *x, y, z*∈ T\F.
Since T\F is completely prime ideal of T, then *xyz*∈ T\F. It is a contradiction.
Thus *x, y, z* ∈ F. Therefore F is a ternary filter of T.

Corollary 3.1.8: Let T be a ternary semigroup. If F is a ternary filter, then T\F is a prime ideal of T or empty.

Proof: Since F is a filter of T. By theorem 3.1.7, T\F is a completely prime ideal of T or empty. By theorem 2.16, T\F is a prime ideal of T or empty.

Corollary 3.1.9: A nonempty subset F of a commutative ternary semigroup T is a ternary filter if and only if T\F is a prime ideal of T or empty.

Proof: Suppose that T\F is a filter of commutative ternary semigroup T. By corollary 3.1.8, T\F is prime ideal of T or empty.
Conversely suppose that T\F is a prime ideal of T or empty. If T\F = ∅, then F = T. Thus F is a filter of T.
Assume that T\F is a prime ideal of T. By theorem 2.17, T\F is a completely prime ideal of T or empty. By theorem 3.1.7, F is a ternary filter of T.

Theorem 3.1.10: Every ternary filter F of a ternary semigroup T is a 3-system of T.

Proof: Suppose that F is a ternary filter of a ternary semigroup T. By corollary 3.1.8,T\F is a prime ideal of T. By theorem 2.19, T\ (T\F) = F is a 3-system of T or empty.

Theorem 3.1.11: Let T be a ternary semigroup. If F is a ternary filter, then T\F is a completely semi prime ideal of T.

Proof: Since F is a ternary filter of a ternary semigroup T, by theorem 3.1.7, T\F is a completely prime ideal of T. By theorem 2.25, T\F is a completely semiprime ideal of T.

Theorem 3.1.12: Every ternary filter F of a ternary semigroup T is a *d*-system of T.

Proof: Since F is a ternary filter of a ternary semigroup T, by theorem 3.1.11, T\F is a completely semiprime ideal of T. By theorem 2.27, T\(T\F) = F is a *d*-system of T or empty.

Theorem 3.1.13: Let T be a ternary semigroup. If F is a filter of T, then T\F is a semiprime ideal of T.

Proof: Since F is a ternary filter of a ternary semigroup T. By theorem 3.1.7, T\F is a completely prime ideal of T. By theorem 2.24, T\F is a completely semiprime ideal of T.By theorem 2.29, T\F is a semiprime ideal of T.

Theorem 3.1.14: Every ternary filter F of a ternary semigroup T is a 3^*-system of T.

Proof: Since F is a ternary filter of a ternary semigroup T. By theorem 3.1.13, T\F is a semiprime ideal of T. By theorem 2.32, T\ (T\F) = F is a 3^*-system of T.

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