# PRIMARY DECOMPOSITION IN NEAR SUBTRACTION SEMIGROUPS

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**Abstract**: The present research article has to initiate the content of primary decomposition in Near subtraction semigroup. Also investigated the properties of prime ideals of a near subtraction semigroup. The investigator also developed the new concept of Noetherian semigroup and Artinian semigroup and duo Noetherian near subtraction semigroup and some of the results were proved.

**Keywords:**duo Noetherian near subtraction semigroup, primary decomposition in Near subtraction semigroup, Noetherian semigroup, Artinian semigroup.

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## 1. Introduction:

The concept of primary ideals in semigroup was studied by A. Anjaneylu in 1980 **[1]** about the primary ideals in semigroups. Later D.Madhusudana Rao[10 ] was introduced the same concept to gamma semigroups in 2010. Further A.GangadharRao[16] extended the concept to duo-gamma semigroups. Now in this paper we used the same concept to study the primary ideals in near subtraction semigroups.

## 2. Preliminaries:

For preliminaries refer the reference [2] and their references

## 3. PRIMARY DECOMPOSITION IN NEAR SUBTRACTION SEMIGROUPS

**DEFINITION 3.1 :**Let P be prime ideal in a near subtraction semigroup X. A primary ideal A in X is said to be **P-primary**or P is a prime ideal belonging to A provided $\sqrt{A} = P$.

**THEOREM 3.2 : If $A_1, A_2, \ldots, A_n$ are P-primary ideals in a near subtraction semigroup X, then $\bigcap_{i=1}^{n} A_i$ is also a P-primary ideal.**

**Proof :**Let $A = \bigcap_{i=1}^{n} A_i$ . Then $\sqrt{A} = \sqrt{\bigcap_{i=1}^{n} A_i} = \bigcap_{i=1}^{n}\sqrt{A_i} = \cap P = P$.

Suppose that $<a><b> \subseteq$ A and $b \notin$ A. $b \notin$ A implies $b \notin A_i$ for some $i$. $<a><b> \subseteq A_i$ and $b \notin A_i$, since $A_i$ is a primary ideal, we have $a \in \sqrt{A_i}$ = P = $\sqrt{A} \Rightarrow a \in \sqrt{A}$. So A is left primary ideal. Similarly we can show that A is right primary ideal. Thus A is a primary ideal. Hence A is P-primary ideal.

**DEFINITION 3.3 :**An ideal A in a near subtraction semigroup X is said to have **left primary decomposition** if $A = A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_n$ where each $A_i$ is a left primary ideal. If no $A_i$ contains $A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_{i--1} \cap A_{i+1} \cap \ldots.. \cap A_n$ and the radicals $P_i$ of the ideals $A_i$ are all distinct, then the left primary decomposition is said to be **reduced**. If $P_i$ is minimal in the set $\{P_1, P_2, P_3, \ldots., P_n\}$ then $P_i$ is said to be**isolated prime.**

**DEFINITION 3.4 :**An ideal A in a near subtraction semigroup X is said to have **right primary decomposition** if $A = A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_n$ where each $A_i$ is a right primary ideal. If no $A_i$ contains $A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_{i--1} \cap A_{i+1} \cap \ldots.. \cap A_n$ and the radicals $P_i$ of the ideals $A_i$ are all distinct, then the right primary decomposition is said to be **reduced**. If $P_i$ is minimal in the set $\{P_1, P_2, P_3, \ldots., P_n\}$ then $P_i$ is said to be**isolated prime.**

**DEFINITION 3.5 :**An ideal A of a near subtraction semigroup X is said to have a **primary decomposition** if $A = A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_n$ where each $A_i$ is a right primary ideal. If no $A_i$ contains $A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_{i--1} \cap A_{i+1} \cap \ldots.. \cap A_n$ and the radicals $P_i$ of the ideals $A_i$ are all distinct, then the primary decomposition is said to be **reduced**. If $P_i$ is minimal in the set $\{P_1, P_2, P_3, \ldots., P_n\}$ then $P_i$ is said to be**isolated prime.**

**DEFINITION 3.6 :**A near subtraction semigroup X is said to be a **Noetherian semigroup** provided every ascending chain of ideals becomes stationary.

**DEFINITION 3.7 :**A near subtraction semigroup X is said to be a **Artinian semigroup** provided every descending chain of ideals becomes stationary.

**THEOREM 3.8 : If an ideal A in a near subtraction semigroup X has a primary decomposition, then A has a reduced primary decomposition.**

**Proof:** If $A = A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_n$ where each $A_i$ is primary ideal and some $A_i$ contains $A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_{i--1} \cap A_{i+1} \cap \ldots.. \cap A_n$ **,**

then $A = A_1 \cap A_2 \cap A_3 \cap \ldots.. \cap A_{i--1} \cap A_{i+1} \cap \ldots.. \cap A_n$ is also a primary decomposition.

By thus eliminating the superfluous $A_i$ reindexing we have $A = A_1 \cap A_2 \cap A_3 \cap \ldots\ldots \cap A_k$ with no $A_i$ containing the intersection of other $A_j$. Let $P_1, P_2, \ldots., P_r$ be the distinct prime ideals in the set $\sqrt{A_1}, \sqrt{A_2}, \ldots.\sqrt{A_k}$ . Let $A_i'$ , $1 \le i \le r$ be the intersection of all $A_j$`s belonging to the prime $P_i$. By theorem 3.2,each $A_i^1$is primary for $P_i$. Clearly no $A_i'$ contains the intersection of all other $A_j'$ . Therefore $A = \bigcap_{i=1}^{k} A_i = \bigcap_{i=1}^{r} A_i'$ and hence A has a reduced primary decomposition.

**NOTE 3.9 :**It is well known that every ideal has a reduced primary decomposition in a commutative Noetherian near subtraction semigroup. But in the case of an arbitrary near subtraction semigroup it is not necessarily true that every ideal has a primary decomposition even if the near subtraction semigroup is finite and pseudo symmetric.

**Example 3.10 :** Assume that X = { *x*,*y*,*z*} in which '-'and '.' are defined as follows:

| . | *x* | *y* | *z* |
|---|---|---|---|
| *x* | *x* | *x* | *x* |
| *y* | *x* | *x* | *x* |
| *z* | *x* | *y* | *z* |

Then (X, -, .) is a near subtraction semigroup.

| - | *x* | *y* | *z* |
|---|---|---|---|
| *x* | *x* | *x* | *x* |
| *y* | *y* | *x* | *y* |
| *z* | *z* | *z* | *x* |

Since {*b*, *c*} and {*a*, *b*, *c*} are the only primary ideals and hence {*a*} has no primary decomposition.

**DEFINITION 3.11 :**A near subtraction semigroup X is said to be a ***left duo near subtraction semigroup***provided every left ideal of X is a two sided ideal of X.

**DEFINITION 3.12 :**A near subtraction semigroup X is said to bea ***right duo near subtraction semigroup*** provided every right ideal of X is a two sided ideal of X.

**DEFINITION 3.13 :**A near subtraction semigroup X is said to be a ***duo near subtraction semigroup***provided it is both a left duo near subtraction semigroup and a right duo near subtraction semigroup.

**REMARK 3.14: Let A be a semipseudo symmetric ideal of a near subtraction semigroup X. Then the following are equivalent.**

1) **$A_1$=The intersection of all completely prime ideals of X containing A.**
2) $A_1^1$= **The intersection of all minimal completely prime ideals of X containing A.**
3) $A_1^{11}$ **= The minimal completely semiprime ideal of X relative to containing A.**
4) **$A_2$= {$x$∈X :$x^n$∈A for some natural number n}**
5) **$A_3$= The intersection of all prime ideals of X containing A.**
6) $A_3^1$**= The intersection of all minimal prime ideals of X containing A.**
7) $A_3^{11}$ **= The minimal semiprime ideal of X relative to containing A.**
8) **$A_4$ = {$x$∈X :$\langle x\rangle^n$⊆A for some natural number n}**

**REMARK 3.15: Let X be a near subtraction semigroup and A be an ideal in X. Then A is pseudo symmetric if and only if for all $a\in$X the set $A_r(a)$ = { $x\in$X : $ax\in$A } is an ideal of X.**

**REMARK 3.16: If A is a pseudo symmetric ideal of a near subtraction semigroup X then $A_2$ = $A_4$.**

**THEOREM 3.17 : Every left(right) duo near subtraction semigroup X is a pseudo symmetric near subtraction semigroup.**

***Proof* :**Let X be a left duo near subtraction semigroup and A be any ideal of X.

Suppose $a$∈X. Let $A_l(a)$ = { $x$∈ X :$xa$∈A}.

Let $x$, $y\in A_l(a)\Rightarrow xa$, $ya$∈ A.

$(x – y)a = xa – ya$∈ A, since A is an ideal of X and $xa$, $ya$∈ A.

Therefore $x – y\in A_l(a)$ and hence $A_l(a)$ is a sub algebra of X.

Let $x\in A_l(a)\Rightarrow xa$∈A. $xa$∈A, A is an ideal ⇒$sxa$∈A for all $s$∈ X

⇒$sx\in A_l(a)$ for all $s$∈ X. Therefore $A_l(a)$ is a left ideal of X for all $a$∈X.

Since X is a left duo near subtraction semigroup, $A_l(a)$ is an ideal of X.

So by Remark 3.16, A is a pseudo symmetric ideal of X.

Therefore X is a pseudo symmetric Semigroup.

**COROLLARY 3.18: Every duo near subtraction semigroup is a pseudo symmetric near subtraction semigroup.**

***Proof* :**By theorem 3.17, we conclude that every duo near subtraction semigroup X is a pseudo symmetric near subtraction semigroup.

**THEOREM 3.19 : Every ideal in a (left, right) duo noetherian near subtraction semigroup X has a reduced (left, right) primary decomposition.**

**Proof :**Let $\Sigma$ be the collection of all ideals in X which has no primary decomposition.
If $\Sigma$ is nonempty, then since S is Noetherian, $\Sigma$ contains maximal elements. Let C be a maximal element in $\Sigma$. Clearly C is not primary. Suppose C is not left primary, then there exists elements *a, b* in X such that $<a><b> \subseteq$ C, $b \notin$ C and $a \notin \sqrt{C}$. Since X is a duo near subtraction semigroup, By theorem 3.18, C is a semi pseudo symmetric ideal, and hence by the remark 3.14, $\sqrt{C}$ = { $x \in$ X : $x^n \in$ C for some natural number *n*}. Therefore $a^n \notin$ C for any natural number *n*. For any natural number *n*, write $B_n$ = {$x \in$ X :$a^n x \in$ C }. Now $B_1 \subseteq B_2 \subseteq$ ,….. is an ascending chain of ideas in X. Since X is Noetherian, there is a natural number *k* such that $B_k = B_i$ for all $i \geq k$. Since $b \in B_k$, we have $B_k$ contains C properly. Write $D = a^k S \cup C$. Now $a^{k+1} \in$ D. Since X is a duo near subtraction semigroup, D is an ideal in X and containing C properly. Now we prove that $C = B_k \cap D$. Cleary $C \subseteq B_k \cap D$. If $x \in B_k \cap D$ and $x \notin$ C, then $x = a^k y$ for some $y \in$ X. Now $x \in B_k \Rightarrow a^k x \in$ C. Therefore $a^{2k} y = a^k . a^k y = a^k x \in C$. Therefore $y \in B_{2k} = B_k$. Thus $y \in B_k \Rightarrow x = a^k y \in C \Rightarrow x \in C$ .It is a contradiction. Thus C is left primary.Similarly, we can show that C is right primary. Hence C is primary. Therefore $\Sigma$ is empty. Thus, every ideal in a duo Noetherian near subtraction semigroup has a primary decomposition and hence by the known result, every ideal has a reduced primary decomposition.

**COROLLARY 3.20 : Every ideal in a generalized commutative Noetherian near subtraction semigroup has a right reduced primary decomposition.**

**Proof :**Since every generalized commutative near subtraction semigroup is a left duo near subtraction semigroup, and hence the proof follows from theorem 3.19.

**NOTATION 3.21 :**Let A and B be two ideals in a near subtraction semigroup X. Then we denote $A^l(B)=\{x\in X:\ <x>B\subseteq A\}$ and $A^r(B)=\{x\in X: B<x>\subseteq A\}$. Clearly $A^l(B)$ and $A^r(B)$ are ideals of X containing A.

**THEOREM 3.22 : Let A and B be two ideals of a near subtraction semigroup X.**

1) **If A is a left primary ideal of X, then $A^l(B)$ is a left primary ideal.**
2) **If A is a right primary ideal of X, then $A^r(B)$ is a right primary ideal.**

**Proof :**(1)If B$\subseteq$A, then clearly $A^l(B)=X$. Suppose B$\not\subset$A. Let $b\in$B\A and $x\in A^l(B)$. $x \in A^l(B)$ implies $<x>B\subseteq A$. So $<x><b>\subseteq$A.

Since $b\notin$A, we have $x\in\sqrt{A}$, therefore $A^l(B)\subseteq\sqrt{A}$.

Since $A\subseteq A^l(B)\subseteq\sqrt{A}\Rightarrow\sqrt{A}\subseteq\sqrt{A^l(B)}\subseteq\sqrt{\sqrt{A}}$

$\Rightarrow\sqrt{A}\subseteq\sqrt{A^l(B)}\subseteq\sqrt{A}\Rightarrow\sqrt{A}=\sqrt{A^l(B)}$. Let $<x><y>\subseteq A^l(B)$ and $y\notin A^l(B)$.

Now $<x><y>B\subseteq A$. If $x\notin\sqrt{A^l(B)}=\sqrt{A}$ then $<y>B\subseteq A$ and hence $y\in A^l(B)$.

This is a contradiction. So $x\in\sqrt{A^l(B)}$. Therefore $A^l(B)$ is a left primary ideal.

(2) The proof is similar to (1).

**THEOREM 3.23 : If Q is a P-primary ideal and if A$\not\subset$P, then $Q^l(A)=Q^r(A)=Q$. And also if $A\subseteq P$ and A$\not\subseteq$Q , then $\sqrt{Q^l(A)}=\sqrt{Q^r(A)}=\sqrt{Q}$.**

**Proof:**Clearly Q$\subseteq$$Q^l$(A). Let $x\in Q^l(A)$. Then $<x>A\subseteq Q$. Since A $\not\subseteq$ P, there exists $a\in$ A\P. Now $<x><a>\subseteq Q$ and $a\notin\sqrt{Q}$. So $x\in Q$. Hence $Q^l(A)\subseteq Q$. Therefore $Q=Q^l(A)$. Similarly we can show that $Q^r(A)=Q$. Therefore $Q^l(A)=Q^r(A)=Q$.

Hence clearly by the theorem 3.22, $\sqrt{Q^l(A)}=\sqrt{Q^r(A)}=\sqrt{Q}$.

**THEOREM 3.24 : If $A_1$, $A_2$, ….,$A_n$, B are ideals of a semigroup X, then**

$[\bigcap_{i=1}^{n} A_i]^l(B) = \bigcap_{i=1}^{n}(A_i)^l(B)$.

**Proof :**Let $x \in [\bigcap_{i=1}^{n} A_i]^l(B)$. Then $<x>B \subseteq \bigcap_{i=1}^{n} A_i \Rightarrow <x>B \subseteq A_i$ for i = 1,2, ….,n

$\Rightarrow x \in A_i^{\,l}(B)$ for i = 1,2, ….,n. $\Rightarrow x \in \bigcap_{i=1}^{n}(A_i)^l(B)$. Therefore $[\bigcap_{i=1}^{n} A_i]^l(B) \subseteq \bigcap_{i=1}^{n}(A_i)^l(B)$. Similarly we can show that $\bigcap_{i=1}^{n}(A_i)^l(B) \subseteq [\bigcap_{i=1}^{n} A_i]^l(B)$. Hence $[\bigcap_{i=1}^{n} A_i]^l(B) = \bigcap_{i=1}^{n}(A_i)^l(B)$.

**THEOREM 3.25 : (UNIQUENESS THEOREM) Suppose an ideal A in a near subtraction semigroup X has two reduced (one sided) primary decompositions** $A = A_1 \cap A_2 \cap .... \cap A_k = B_1 \cap B_2 \cap ....B_s$, **where $A_i$ is $P_i$-primary and $B_j$ is $Q_j$-primary. Then *k* = *s* and after reindexing if necessary, $P_i = Q_i$ for i = 1, 2, 3, …, k. Further if each $P_i$ is an isolated prime, then $A_i = B_i$ for i = 1, 2, 3, …., n.**

**Proof :**Let $P_k$ be the maximal element in the set $P_1$, $P_2$, …,$P_k$, $Q_1$, $Q_2$, …., $Q_s$. Now we show that $P_k$ occurs among $Q_1$, $Q_2$, …., $Q_s$. For this it is enough to show that $P_k \subseteq Q_j$ for some j.

If $A_k \subseteq Q_j$ for some j, then $P_k = \sqrt{A_k} \subseteq Q_j$.

Suppose $A_k \not\subseteq Q_j$ for all j, then by the known result $B_j^{\,l} = B_j \forall j$.

Now $A^l(A_k) = (B_1 \cap B_2 \cap ..... \cap B_s)^l(A_k) = B_1^{\,l}(A_k) \cap B_2^{\,l}(A_k) \cap ..... \cap B_s^{\,l}(A_k) = A$

But on the other hand if $1 \le i < k$, then $P_k \not\subseteq P_i$ and therefore $A_k \not\subseteq P_i$, so that $A_i^{\,l}(A_k) = A_i$ and $A_k^{\,l}(A_k) = S$. We have

$A^l(A_k) = (A_1 \cap A_2 \cap ...... \cap A_k)^l(A_k) = A_1^{\,l}(A_k) \cap A_2^l(A_k) ...... \cap A_k^l(A_k) = A_1 \cap A_2 \cap ......A_{k-1}$

$\therefore A = A_1 \cap A_2 \cap ...... \cap A_{k-1}$. It is a contradiction to the fact that given decomposition is reduced. Thus $A_k \subseteq Q_j$ for some j and hence $P_k \subseteq Q_j$. Therefore $P_k = Q_j$. Without loss of generality we may assume that $P_k = Q_s$. Let $B = A_k \cap B_s$.

By the theorem 3.2,B is a primary ideal and $P_k = Q_s = P$ (say) is a prime ideal belonging to B. Since $P \not\subseteq P_i$ for all i, $1 \le i < k$ and $B \subseteq A_k$. We have $A_i{}^l(B) = A_i$ and $A_k{}^l(B) = S$ .

Therefore $A^l(B) = A_1 \cap A_2 \cap .... \cap A_{k-1}$.

Similarly, we can show that, $A^l(B) = B_1 \cap B_2 \cap .... \cap B_{s-1}$.

Therefore $A^l(B) = A_1 \cap A_2 \cap .... \cap A_{k-1} = B_1 \cap B_2 \cap .... \cap B_{s-1}$ are two reduced primary decompositions for $A^l(B)$. By continuing the above process, we get $k = s$ and $P_i = Q_i$ for

$i = 1, 2, ...., k$. Suppose $P_i^{\prime}$ s are isolated primes. If $A_1 \subseteq B_1$, then since $B_1$ is primary and $A_1 A_2 .... A_k \subseteq B_1 \cap B_2 \cap .... \cap B_k \subseteq B_1$, we have $A_2 A_3 .... A_k \subseteq \sqrt{B_1} = P_1$.

Now $P_2 P_3 .... P_k = \sqrt{A_2 A_3 .... A_k} = P_1$. Since $P_1$ is a prime ideal $P_i \subseteq P_1$ for some $1 < i \le k$. This is a contradiction to the fact that $P_1$ is an isolated prime. So $A_1 \subseteq B_1$. Similarly we can show that $B_1 \subseteq A_1$. By continuing in this way we get $A_i = B_i$ for $i = 1, 2, ...., k$. This completes the proof of the theorem.

**Conclusion:** Mainly in this research article, we studied primary decomposition in Near subtraction semigroup.

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