

NANO g^* sr CLOSED SETS IN NANO TOPOLOGICAL SPACES

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Abstract

The primary focus of this article is to develop, a fresh concept of sets namely Ng^* sr closed sets. The goal of this research is to go over the concepts of Ng^* sr closed sets and open sets in nano topological spaces. An appropriate illustration is given to study the properties of the above sets. The present relations between some of these sets in nano topological space are provided.

Keywords: N closed set; N regular closed set; Ng closed set; Ngr closed set; Ng^* closed set; Ng^* s closed; Ng^* sr closed set

Introduction

Lellis Thivagar (2012) introduced the concept of upper and lower approximations of X in nano topological spaces and also developed N closed sets, N interior and closure of a set. Bhuvaneswari (2014) defined Ng -closed, Ngs closed, Nag closed, $Ng\alpha$ closed, Ngr closed and Nrg closed, Ngp closed sets and Npg closed sets. Rajendran *et al.* (2015) developed the concept of Ng^* closed sets. introduced the concept of Ng^* s closed sets. Sasikala and Sreeja (2015) introduced g^* sr closed sets in Topological spaces and deliberate some of their properties.

Preliminaries

Definition 1: Lellis Thivagar (2012) Let W be a non-empty finite set of objects called universe and R be an equivalence relation on W named as the obscure relation. Elements belonging to the similar equivalence class are said to be indistinct with one another.

The pair (W, R) is said to be approximation space. Let $x \subseteq W$

1. Lower Approximation: $L_R(x) = W \{R(x) : R(x) \subseteq x\}$,
2. Upper Approximation: $U_R(x) = W \{R(x) : R(x) \cap x \neq \varnothing\}$.

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3. Boundary Region: $B_R(x) = U_R(x) - L_R(x)$.

Remark 2: If (W, R) is an approximation space and $X, Y \subseteq W$, then

- ✓ $L_R(X) \subseteq X \subseteq U_R(X)$
- ✓ $L_R(\varphi) = U_R(\varphi)$ and $L_R(W) = U_R(W) = W$
- ✓ $U_R(X \cup Y) = U_R(X) \cup U_R(Y)$
- ✓ $U_R(X \cap Y) \subseteq U_R(X) \cap U_R(Y)$
- ✓ $L_R(X \cup Y) \supseteq L_R(X) \cup L_R(Y)$
- ✓ $L_R(X \cap Y) = L_R(X) \cap L_R(Y)$
- ✓ $L_R(X) \subseteq L_R(Y)$ and $U_R(X) \subseteq U_R(Y)$ whenever $X \subseteq Y$
- ✓ $U_R(X^c) = [L_R(X)]^c$ and $L_R(X^c) = [U_R(X)]^c$
- ✓ $U_R[U_R(X)] = L_R[U_R(X)] = U_R(X)$
- ✓ $L_R[L_R(X)] = U_R[L_R(X)] = L_R(X)$

Definition 3: Lellis Thivagar (2012) Let W be the cosmos, R be an equivalence relation on W and $\tau_R^{(x)} = \{W, \Phi, U_R(X), L_R(X), B_R(X)\}$ where $X \subseteq W$. Then $\tau_R^{(x)}$ satisfies the following axioms.

1. W and $\varphi \in \tau_R^{(x)}$.
2. The union of the elements of any sub-collection of $\tau_R^{(x)}$ is in $\tau_R^{(x)}$
3. The intersection of the elements of any finite sub-collection of $\tau_R^{(x)}$ is in $\tau_R^{(x)}$

i.e., $\tau_R^{(x)}$ is a topology on W called the Nano topology on W .

$(W, \tau_R^{(x)})$ is called the nano topological space.

Sets of $(\tau_R^{(x)})$ are called as Nano open sets in W .

Sets of $[\tau_R^{(x)}]^c$ are called Nano closed sets.

Remark 4: Lellis Thivagar (2012)

If $\tau_R^{(x)}$ is the Nano topology on W with respect to X . Then the set $Z = \{U, L_R(X), B_R(X)\}$ is the basis for $\tau_R^{(x)}$.

Definition 5: Lellis Thivagar (2012)

If $(W, \tau_R^{(x)})$ is a Nano topological space where $X \subseteq W$ and if $A \subseteq W$, then

- ✓ The N int of the set A is defined as the U of all N open subsets. Thus $N \text{ int}(A)$ is the largest N open subset of A .
- ✓ The N cl of the set A is defined as the $\cap$ of all N closed containing in A . Thus $N \text{ cl}(A)$ is the smallest N closed set containing A .

Ng*sr closed sets

Definition 1:

Let $(W, \tau_R^{(x)})$ be a nano topological space. A subset A of $(W, \tau_R^{(x)})$ is said to be Ng*sr - closed

set if $Nrcl(A) \subseteq W$ whenever $A \subseteq W$ and W are Ng open.

Illustration 2: Let $W = \{a, b, c, d\}$ with $W/R = \{\{a\}, \{b\}, \{c, d\}\}$ and $X = \{a, c\}$. Then $\tau_R^{(x)} = \{W, \varphi, \{a\}, \{c, d\}, \{a, c, d\}\}$ which is nano open sets. Then the

1. N closed set = $\{W, \varphi, \{b\}, \{a, b\}, \{b, c, d\}\}$
2. N semi closed sets = $\{W, \varphi, \{a\}, \{b\}, \{a, b\}, \{c, d\}, \{b, c, d\}\}$
3. N regular closed set = $\{W, \varphi, \{b\}, \{a, b\}, \{b, c, d\}, \{b, d\}, \{a, b, c\}, \{a, b, d\}, \{b, c, d\}\}$
4. Ng closed set = $\{W, \varphi, \{b\}, \{a, b\}, \{b, c\}, \{b, d\}, \{a, b, c\}, \{a, b, d\}, \{b, c, d\}\}$
5. N gp closed set = $\{W, \varphi, \{b\}, \{a, b\}, \{b, c\}, \{b, d\}, \{a, b, c\}, \{a, b, d\}, \{b, c, d\}\}$
6. N gs closed set = $\{W, \varphi, \{a\}, \{b\}, \{c\}, \{d\}, \{a, b\}, \{b, c\}, \{b, d\}, \{c, d\}, \{a, b, c\}, \{a, b, d\}, \{b, c, d\}\}$
7. N gr closed set = $\{W, \varphi, \{b\}, \{c\}, \{d\}, \{b, c\}, \{b, d\}, \{a, b\}, \{a, b, c\}, \{b, c, d\}, \{a, b, d\}\}$
8. N g* closed set = $\{W, \varphi, \{b\}, \{a, b\}, \{b, c\}, \{b, d\}, \{a, b, c\}, \{a, b, d\}, \{b, c, d\}\}$
9. Ng*s closed set = $\{W, \varphi, \{a\}, \{b\}, \{c\}, \{d\}, \{a, b\}, \{a, c\}, \{a, d\}, \{b, c\}, \{b, d\}, \{c, d\}, \{a, b, c\}, \{a, b, d\}, \{a, c, d\}, \{b, c, d\}\}$
10. N g*sr closed set = $\{W, \varphi, \{b\}, \{a, b\}, \{b, c\}, \{b, d\}, \{a, b, c\}, \{a, b, d\}, \{b, c, d\}\}$

Theorem 3:

If A is N closed set in $(W, \tau_R^{(x)})$, then it is a Ng*sr closed set but not the converse.

Proof:

Let A be an N closed set of W and $A \subseteq V$, where V is Ng open in W . Since A is N closed, we have $Ncl(A) = A \subseteq V$. That is $Ncl(A) \subseteq V$. Also $Nrcl(A) \subseteq Ncl(A)$ implies $Nrcl(A) \subseteq V$, where V is Ng open in W . Therefore A is a Ng*sr closed set.

Illustration 4:

In Illustration 3.2, the subsets $\{b, d\}$ are Ng*srclosed but not N closed set.

Theorem 5:

If A is Ng-closed in $(W, \tau_R^{(x)})$, then it is Ng*sr closed set.

Proof:

Let A be a Ng closed set. Then $Ncl(A) \subseteq V$ whenever $A \subseteq V$ and V is N open in W , since every N open set is Ng open set. So V is Ng open set in W . We have $Nrcl(A) \subseteq Ncl(A)$ which implies $Nrcl(A) \subseteq V, A \subseteq V, V$ is Ng open in W . Hence A is Ng*sr closed set.

Theorem 6:

If A is Ng^* closed in $(W, \tau_R^{(x)})$, then it is Ng^* sr closed set.

Proof:

Let A be a Ng^* closed set of U and $A \subseteq V$, where V is Ng open in W . Since A is Ng^* closed we have $Ncl(A) = A$. So $A \subseteq V$ implies $Ncl(A) \subseteq V$. But $Nrcl(A)$

$\subseteq Ncl(A)$ implies $Nrcl(A) \subseteq V$, $A \subseteq V$, V is Ng s open in W . Therefore A is Ng^* sr closed set.

Theorem 7:

If A is Ng^* s closed in $(U, \tau_R^{(x)})$, then it is Ng^* sr closed set.

Proof:

Let A be a Ng^* s closed set of W and $A \subseteq V$, where V is Ng s open in W . Since A is Ng^* s closed we have $Nrcl(A) = A$. So $A \subseteq V$ implies $Nscl(A) \subseteq W$. But $Nscl(A)$

$\subseteq Nrcl(A)$ implies $Nscl(A) \subseteq V$, $A \subseteq V$, V is Ng s open in W . Therefore A is Ng^* sr closed set.

Theorem 8:

The Finite union of two Ng^* sr closed set in $(W, \tau_R^{(x)})$, is also an Ng^* sr closed $(W, \tau_R^{(x)})$,

Proof:

Let A and B be two Ng^* sr closed set in $(W, \tau_R^{(x)})$, Let V be a Ng s-open set in W , such that $A \subseteq V$ and $B \subseteq V$. Then we have $A \cup B \subseteq V$. Since A and B are Ng^* sr closed in $(W, \tau_R^{(x)})$. This implies $Nrcl(A) \subseteq V$ and $Nrcl(B) \subseteq V$. Now $Nrcl(A \cup B) = Nrcl(A) \cup Nrcl(B)$

$\subseteq V$. Thus we have $Nrcl(A \cup B) \subseteq V$, whenever $A \cup B \subseteq V$, where V is Ng s open set in $(U, \tau_R^{(x)})$. This implies $A \cup B$ is a Ng^* sr closed set in $(W, \tau_R^{(x)})$,

Remark 9:

The intersection of two Ng^* sr closed sets in $(W, \tau_R^{(x)})$, is also a Ng^* sr closed set in $(W, \tau_R^{(x)})$.

Illustration 10:

Let $W = \{a, b, c, d\}$ with $W/R = \{\{a\}, \{b\}, \{c, d\}\}$ and $X = \{a, c\}$. Then $\tau_R^{(x)} = \{W, \emptyset, \{a\}, \{c, d\}, \{a, c, d\}\}$. The Ng^* sr-closed set $= \{W, \emptyset, \{b\}, \{a, b\}, \{b, c\}, \{b, d\}, \{a, b, c\}, \{a, b, d\}, \{b, c, d\}\}$ Here $\{b, c\} \cap \{b, d\} = \{b\}$ is also a Ng^* sr closed set.

Theorem 11:

Let A be a Ng^* sr closed subset of $(W, \tau_R^{(x)})$. If $A \subseteq B \subseteq Nrcl(A)$, then B is also a Ng^* sr closed subset of $(W, \tau_R^{(x)})$.

Proof:

Let V be a Ng s open set of a nano g^* sr-closed subset of $\tau_R^{(x)}$ such that $B \subseteq V$, as $A \subseteq B$, we have $A \subseteq V$. As A is Ng^* sr closed set, $Nrcl(A) \subseteq V$. Given $B \subseteq Nrcl(A)$. we have $Nrcl(A) \subseteq Nrcl(B)$ and $Nrcl(A) \subseteq V$, we have $Nrcl(B) \subseteq V$, whenever $B \subseteq V$ and V is Ng s open. Hence B is also a Ng^* sr closed subset of $\tau_R^{(x)}$.

Theorem 12:

If $x \in Nrcl(A)$ iff $V \cap A \neq \emptyset$ for every regular open set W containing x .

Proof:

Suppose that $x \in Nrcl(A)$. To show that $V \cap A \neq \emptyset$ for every Ng s open set W containing x such that $V \cap A = \emptyset$. Then $A \subseteq W$ and W is Ng s closed set. Since $A \subseteq W$, $Nrcl(A) \subseteq Nrcl(W)^c$. Since $x \in Nrcl(A)$ we have $x \in Nrcl(W)^c$. Since W is Ng s closed set. We have $x \in W^c$. Hence $x \notin W$ which is a contradiction that $x \in W$. Therefore $V \cap A \neq \emptyset$. Hence $V \cap A \neq \emptyset$ for every Ng s open set V containing x .

On a contrary, suppose that $V \cap A \neq \emptyset$ for every open set containing x . To show that $x \in Nrcl(A)$. Suppose that $x \notin Nrcl(A)$. Then there exists an Ng s open set W containing x such that $V \cap A = \emptyset$. This is a contradiction to $V \cap A \neq \emptyset$. Hence $x \in Nrcl(A)$.

Theorem 13:

A subset A of X is Ng^* sr closed set in X iff $Nscl(A) - A$ contains no non-empty Ng s -closed set in X .

Proof:

Suppose that F is a non-empty Ng s closed subset of $Nscl(A) - A$. Now $F \subseteq Nrcl(A) - A$. Then $F \subseteq Nscl(A) \cap A^c$. Therefore $F \subseteq Nscl(A)$ and $F \subseteq A^c$. Since F^c is Ng s open set and A is Ng^* sr -closed, $Nscl(A) \subseteq F^c$. That is $F \subseteq Nscl(A)^c$. Since F^c is Ng s -open set and A is Ng^* sr closed, $Nscl(A) \subseteq F^c$. That is $F \subseteq Nscl(A)^c$. Hence $F \subseteq Nscl(A) \cap [Nscl(A)]^c$. That is $F = \emptyset$. Thus $Nscl(A) - A$ contains no non-empty Ng s -closed set.

On a contrary, assume that $Nscl(A) - A$ contains no non-empty Ng s closed set. Let $A \subseteq V$, V is Ng s open. Suppose that $Nscl(A)$ is not contained in V . Then $Nscl(A) \cap V^c$ is a non-empty Ng s closed set and contained in $Nscl(A) - A$ which is a contrary. Therefore $Nscl(A) \subseteq V$ and hence A is Ng^* sr closed set.

Definition 14:

A topological space $(W, \tau_R^{(x)})$, is called a Ng*sr compact space if every Ng*sr covering has a finite subcover.

Theorem 15:

Every closed subset of a Ng*sr compact.

Proof :

Let $(W, \tau_R^{(x)})$, be an Ng*sr -compact space. If A is Ng*sr closed subset of X , then A is Ng*sr compact.

Theorem 16:

Let $(W, \tau_R^{(x)})$, be a compact topological space. If A is Ng*sr closed subset of X , then A is compact.

Proof:

Let $\{W_i\}$ be an open cover of A . Since every open set is gs- open and A is Ng*srclosed. We get $Nscl(A) \subseteq W_i$. Since a closed subset of a compact space is compact, $Nscl(A)$ is compact. Therefore there exists a finite subcover say $\{W_1 \cup W_2 \cup \dots \cup W_n\}$ of $\{W_i\}$ for $Nscl(A)$. So, $A \subseteq Nscl(A) \subseteq \{W_1 \cup W_2 \cup \dots \cup W_n\}$. Therefore A is compact.

Ng*sr - Opensets**Definition 1:**

A subset A of nano topological space $(W, \tau_R^{(x)})$, is called N generalized star semi-regular open set if A^C is Ng*sr closed.

Theorem 2:

1. If A is nano open set in $(W, \tau_R(X))$, then it is Ng*sr open
2. If A is Ng* open set in $(W, \tau_R(X))$, then it is Ng*sr open
3. If A is Ng*s open set in $(W, \tau_R(X))$, then it is Ng*sr open

Proof:

It follows from the Theorem 3.3, 3.6 and 3.7.

Remark 3:

For subset A of nano topological space $(W, \tau_R^{(x)})$,

1. $W - Ng*sr \text{ int}(A) = Ng*sr \text{ cl}(U - A)$
2. $W - Ng*sr \text{ cl}(A) = Ng*sr \text{ int}(U - A)$

Theorem 4:

A subset $A \subseteq W$ is Ng*sr open if and only if $F \subseteq Nrint(A)$ whenever F is Ng closed set and $F \subseteq A$.

Proof:

Let A be Ng*sr open set and suppose $F \subseteq A$, where F is Ng closed. Then $W - A$ is Ng*sr closed set contained in the Ng open set $W - F$. Hence $Nrcl(W - A) \subseteq W - F$. Thus $F \subseteq Nrint(A)$. Conversely, if F is Ng closed set with $F \subseteq Nrint(A)$ and $F \subseteq A$. Then $W - Nrint(A) \subseteq W - F$. Thus $Nrcl(W - A) \subseteq W - F$. Hence $W - A$ is Ng*sr closed set and A is Ng*sr open set.

Theorem 5:

If $Nrint(A) \subseteq B \subseteq A$ and if A is Ng*sr open, then B is Ng*sr open.

Proof:

Let $Nrint(A) \subseteq B \subseteq A$, then $A^C \subseteq B^C \subseteq Nscl(A^C)$, where A^C is Ng*sr closed and hence B^C is also Ng*sr closed by the Orem 3.12. Therefore B is Ng*sr open.

Applications of nano topology

In the context of nano technology, nano topology has demonstrated interesting applications in a variety of sectors, including medicine and healthcare. Medical techniques such as X-rays, ultrasound, and computed tomography (CT) scans are commonly applied to detect kidney stones. These strategies aid in the visualisation and identification of kidney stones in the urinary system, including their presence, size, and location. Illustration:1 Jayalakshmi and Janaki (2017).

In this essay, we tie nano topology to the fundamentals of 'Kidney Stone' via topological factor depletion in a comprehensive information system.

Table 1 below contains information about people who suffer from Dehydration- DH, Diet - DT, Family history - FH, Urinary tract infections - UT, and Excessive Salt - ES consumption.

Table 1. People Survey

People	DH	DT	FH	UT	ES	Result
1	√	√	√			Yes
2	√			√	√	Yes
3		√	√		√	Yes
4	√	√	√			No
5		√	√			No
6		√	√		√	No
7	√		√		√	Yes
8	√		√	√		No

$W = \{1, 2, 3, 4, 5, 6, 7, 8\}$, the group of people and $A = \{\text{Dehydration, Diet, Family history, Urinary tract infections, too much intake of salt, and Kidney Stone}\}$ which his divide dint two classes, $C = \{\text{DH, DT, FH, UT, ES}\}$ and $D = \{\text{Kidney Stone}\}$. The equivalence classes, W/C communicating to CIS given by $W/R(C) = \{\{1,4\}, \{2\}, \{3,6\}, \{5\}, \{7\}, \{8\}\}$.

Type 1: (People with Kidney Stone)

Let $X = \{1, 2, 3, 7\}$, the set of patients with Kidney Stone. Then $LC(X) = \{2, 7\}$, $UC(X) = \{1, 2, 3, 4, 6, 7\}$ and $BR(X) = \{1, 3, 4, 6\}$. Therefore, $rc(X) = \{W, \varnothing, \{2, 7\}, \{1, 2, 3, 4, 6, 7\}, \{1, 3, 4, 6\}\}$.

Step 1: The factor 'Dehydration' is removed from $C, W/R(C-DH) = \{\{1, 4, 5\}, \{2\}, \{3, 6\}, \{7\}, \{8\}\}$ the lower and upper approximations of Communicating to $C-\{DH\}$ are given by $LC-\{DH\}(X) = \{\{2, 7\}\}$, $UC-\{DH\}(X) = \{1, 2, 3, 4, 6, 5, 7\}$ and the communicating boundary region is $BC-\{DH\}(X) = \{1, 3, 4, 6\}$. Therefore the communicating nano topology are given by $rc_{C-\{DH\}}(X) = \{W, \varnothing, \{2, 7\}, \{1, 2, 3, 4, 6, 5, 7\}, \{1, 3, 4, 6\}\} \neq rc(X)$.

Step 2: The factor 'Diet' is removed from $C, W/R(C-DT) = \{\{1, 4\}, \{2\}, \{3, 6\}, \{5\}, \{7\}, \{8\}\}$ and hence $rc_{C-\{DT\}}(X) = \{W, \varnothing, \{2, 7\}, \{1, 2, 3, 4, 6, 7\}, \{1, 3, 4, 6\}\} = rc(X)$.

Step3: The factor 'Family History' is removed from $C, W/R(C-FH) = \{\{1, 4\}, \{2\}, \{3, 6\}, \{5\}, \{7\}, \{8\}\}$ and hence $rc_{C-\{FH\}}(X) = \{W, \varnothing, \{2, 7\}, \{1, 2, 3, 4, 6, 7\}, \{1, 3, 4, 6\}\} = rc(X)$.

Step4: The factor 'Urinary tract infections' is removed from $C, W/R(C-UT) = \{\{1, 4\}, \{2\}, \{3, 6\}, \{5\}, \{7\}, \{8\}\}$ and hence $rc_{C-\{UT\}}(X) = \{W, \varnothing, \{2, 7\}, \{1, 2, 3, 4, 6, 7\}, \{1, 3, 4, 6\}\} = rc(X)$.

Step5: The factor 'Excessive salt' is removed from $C, W/R(C-ES) = \{\{1, 4\}, \{2\}, \{3, 5, 6\}, \{7\}, \{8\}\}$ and hence $rc_{C-\{ES\}}(X) = \{W, \varnothing, \{2, 7\}, \{1, 2, 3, 5, 6, 7\}, \{1, 3, 4, 5, 6\}\} \neq rc(X)$.
CORE = {Dehydration, Excessive salt}.

Type 2: (People without Kidney Stone)

Let $X = \{4, 5, 6, 8\}$, the group of people without kidney stones. Therefore, $rc(X) = \{W, \varnothing, \{5, 8\}, \{1, 3, 4, 5, 6, 8\}, \{1, 3, 4, 6\}\}$.

Step 1: The factor 'Dehydration' is removed from $C, W/R(C-DH) = \{\{1, 4, 5\}, \{2\}, \{3, 6\}, \{7\}, \{8\}\}$. The

refore, $rc_{C-\{DH\}}(X) = \{W, \varnothing, \{8\}, \{1, 3, 4, 5, 6, 8\}, \{1, 3, 4, 5, 6\}\} \neq rc(X)$.

Step 2: The factor 'Diet' is removed from $C, W/R(C-DT) = \{\{1, 4\}, \{2\}, \{3, 6\}, \{5\}, \{7\}, \{8\}\}$ and hence $rc_{C-\{DT\}}(X) = \{W, \varnothing, \{5, 8\}, \{1, 3, 4, 5, 6, 8\}, \{1, 3, 4, 6\}\} = rc(X)$.

Step 3: The factor 'Family History' is removed from $C, W/R(C-FH) = \{\{1, 4\}, \{2\}, \{3, 6\}, \{5\}, \{7\}, \{8\}\}$ and hence $rc_{C-\{FH\}}(X) = \{W, \varnothing, \{5, 8\}, \{1, 3, 4, 5, 6, 8\}, \{1, 3, 4, 6\}\} = rc(X)$.

Step 4: The factor 'Urinary tract infections' is removed from $C, W/R(C-UT) = \{\{1, 4\}, \{2\}, \{3, 6\}, \{5\}, \{7\}, \{8\}\}$ and hence $rc_{C-\{UT\}}(X) = \{W, \varnothing, \{5, 8\}, \{1, 3, 4, 5, 6, 8\}, \{1, 3, 4, 6\}\} = rc(X)$.

Step 5: The factor 'Excessive salt' is removed from $C, W/R(C-ES) = \{\{1, 4\}, \{2\}, \{3, 6\}, \{5\}, \{7\}, \{8\}\}$ and hence $rc_{C-\{ES\}}(X) = \{W, \varnothing, \{8\}, \{1, 3, 4, 5, 6, 7, 8\}, \{1, 3, 4, 5, 6, 7\}\} \neq rc(X)$.

CORE = (Dehydration, Excessive salt) Observation

It is clear from the preceding two categories that the fundamental consequence, which is meant to be the CORE, is DEHYDRATION AND EXCESSIVE SALT. We conclude that the Kidney Stone is caused by dehydration and excessive salt, both of which lead to decreased immunity during KIDNEY STONE.

Conclusion

In this existing real-life scenario, which determined to verify that the attributes deduction is adopted by the nano topology methodology. Through nano topological deduction, the concluding statement draws the conclusion that DEHYDRATION AND EXCESSIVE SALT are the most important reasons for KIDNEY STONE.

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