Comparative study of assessment of water qualities stored in Tamra & Stainless steel vessels with special reference to Sushrut Samhita

A thesis submitted to
Tilak Maharashtra Vidyapeeth, Pune
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In Swasthavritta Subject

Under the Board of Ayurveda Studies

Submitted by

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Under the Guidance of

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July 2016

Certificate

This is to certify that Vd. Miss. Kalpana Krishanarao Jadhav , whose PRN for Ph.D. (Ayurved) is 05610001728 has prepared her Ph.D. thesis (Swasthavritta), titled **"Comparative study of assessment of water qualities stored in *Tamra* & Stainless steel vessels with special reference to *Sushrut Samhita*"** under my supervision after satisfactory research work & discussions.

I recommend that the thesis can be submitted to the Faculty of Ayurved, for PhD, as the work completed by the research scholar is original and not a reputation or duplication of any other previous or ongoing work.

Date: -

Sign of Guide

with seal

Head of the Department
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To,

The Controller of Examinations
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Sub: - Submission of thesis for Ph.D. Swasthavritta (Ayurveda)

Respected Sir,

I the undersigned have been enrolled under Faculty of Ayurveda, TMV, Pune for Ph.D. in Swasthavritta .

I am submitting my thesis for PhD, titled "Comparative study of assessment of water qualities stored in *Tamra* & Stainless steel vessels with special reference to *Sushrut Samhita* ''; for your further suggestions & instructions.

Thanking you.

Yours truly,

Vd. Miss Kalpana Krishnarao Jadhav
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Vd. Kalpana Jadhav

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ABSTRACT

Environmental pollution is a major threat to community health. From this water pollution is very important issue because it is a basic cause for major epidemic diseases e.g. Cholera, Typhoid, Diarrhoea, Hepatitis A etc. & also the safe drinking water is basic need of human being

Current Project is concerned especially for rural population, where there is scarcity of other water purification facilities in rural areas and also purified water supply by local Govt. agencies is not available daily. Since the potable water supply may not be available daily water needs to be stored for minimum 2 to 3 days. So this research project is conducted on Comparative study of assessment of water qualities stored in *Tamra* & Stainless steel vessels

The thesis has been divided into following chapters –

Aims & objectives with brief plan of work are given in the introduction. Chapter Review of literature deals with the valuable references about description of *jala* (water) according to Ayurvedic aspect as well as modern aspect, Review of *tamra* (copper) according to Ayurveda & modern science, Review of water stored in copper vessels. Also it includes the previous work done on water treatment by Ayurvedic methods.

Chapter on Material and Methods brings about details of water testing which includes method of water collection from raw sources & methods of laboratorial testing of water for each parameter. The present study was carried out on river and tube well water stored in both *Tamra* & Stainless Steel Vessels to find out the changes in qualities in terms of physico-chemical & bacteriological parameters like colour, odour, turbidity, temperature ,hardness, pH, TDS, TSS and MPN. Also the subjective (Ayurvedic) parameters *Gandha, Shuddhi* & *Shitata*. Six samples from different sites of each source were collected in every season (*Rutu*) according to Ayurveda i.e. *Varsha, Sharad, Hemant, Shishir , Vasant* & *Grishma* in order to evaluate the changes in water qualities. Collected raw water testing was done first after that storage of water is done up to 48 hrs and observations are taken after 12 hrs , 24 hrs & 48 hrs. This study was carried in village Kodoli from Kolhapur district. For this study both the Vessels are manufactured & purchased from Laxmi Metal, Chavadartale, Tambat Lane, Mahad, Dist – Raigad .

All water testing was done at Environment Science Department of Shivaji Vidyapeeth ,Kolhapur.

Assessment of water qualities of samples are done by comparison between water analysis Laboratorial results from both vessels as well as comparison with Indian Standard Specification

for drinking water. Necessary statistical analysis is done on the data generated during this experimental study.

Detailed discussion regarding review of literature, material and methods, observations and results of this experimental study is done in the chapter namely Discussion. Limitations and scope of the projects are also discussed here.

Effect of water stored in *Tamra* vessel and Stainless Steel vessel has been included in the chapter named Conclusion. Results of the water stored in copper vessel are remarkable.

INTRODUCTION

THE IMPORTANCE OF WATER

With two thirds of the earth's surface covered by water and the human body consisting of 75 percent of it, it is evidently clear that water is one of the prime elements responsible for life on earth. Water circulates through the land just as it does through the human body, transporting, dissolving and replenishing nutrients and organic matter, while carrying away waste material. Further in the body, it regulates the activities of fluids, tissues, cells, lymph, blood and glandular secretions.

An average adult body contains 42 liters of water and with just a small loss of 2.7 liters he or she can suffer from dehydration, displaying symptoms of irritability, fatigue, nervousness, dizziness, weakness, headaches and consequently reach a state of pathology. Dr F. Batmanghelidj, in his book 'your body's many cries for water', gives a wonderful essay on water and its vital role in the health of a water 'starved' society. He writes: "Since the 'water' we drink provides for cell function and its volume requirements, the decrease in our daily water intake affects the efficiency of cell activity, as a result chronic dehydration causes symptoms that equal disease..."

THE PROJECT

Water is a basic need of human being. World health Assembly in a resolution emphasized that safe drinking water is basic element of “Primary Health Care”. Water is also integrated with other PHC components because it is an essential part of health education, food & nutrition and also MCH. For human being water should be easily accessible, adequate in quantity, free from contamination, safe and readily available throughout the year. There can be no state of positive health and well being without safe water.

Water is the sustainer of life for all living being. Water is not only a vital environmental factor to all forms of life, as we know it is essential either directly or indirectly to almost all activities of man and it has also a great role to play in socio economics development of human population.

Environmental pollution is a major threat to community health. Environmental pollution includes air, soil pollution as well as water pollution. Rivers and large tanks are the chief sources of drinking water now. Due to increased human population, unhygienic and unethical man-made activities, these sources of water are become polluted very much. Also industrial wastes and

effluents, chemical pesticides, sewage and sludge, agriculture pollutants, physical pollutants etc. are being allowed into river, lakes, tanks etc. results in to water pollution. Much of the ill health which affects humanity, especially in the developing countries can be traced to lack of safe and wholesome water supply. Hence water pollution is a basic cause for major epidemic diseases e.g. Cholera, Typhoid, Diarrhoea, Hepatitis A etc. None of river has pure water and it is hazardous to health to drink such water without purification. A current method of large scale purification includes storage, filtration, oxygenation and disinfection by chlorine etc. Even with these methods, water dose not became hundred present safe.

Current Project is concerned especially for rural population, as there is a scarcity of large scale water purification facilities in rural areas and even if it is available, it is not consistent. As the potable water supply may not be available daily, water needs to be stored for minimum 2 to 3 days. Due to this several people in rural area are dependent on fresh water supplies from groundwater for domestic purpose as well as for drinking.

Contemporary house hold water purification systems are expensive & are beyond the means of rural population. Also current water filters require regular maintenance & cleaning of filter candles. Moreover the treated water can get contaminated depending on storage conditions. So there is a need of easy & affordable method for water treatment & storage especially for rural population.

As Ayurveda is ancient & classical science, it not only looks into the aspect of diseases & cures but gives prime importance to prevention of diseases & hence maintains a state of equilibrium of all factors within universe.

In Ayurvedic texts various methods for Cleaning, Purification and reduction of turbidity of water are mentioned. In current research project I would like to propose a water treatment method which is based on the reference of *Sushruta Samhita* which will be an economical alternative especially for rural population for household purification & storage of water.

सौवर्णे राजते ताम्रे कांस्ये मणिमयेऽपि वा |
पुष्पावतंसं भौमे वा सुगन्धि सलिलं पिबेत् ||

सुश्रुत सूत्रस्थान ४५/१३

Water stored in metallic vessels like gold, silver, copper, bronze, precious stone or in earthen pots and made fragrant by putting flowers into it should be used for drinking.

In above *shloka, Sushruta* has mentioned simple water storage procedure in various vessels to make it safe for drinking. In this research project I am concentrating only on Copper vessel because these vessels are readily available in rural areas since generations and are comparatively affordable than other metal vessels mentioned in *shloka.*

At the same time this simple storage method is easy to practice and will be useful for mass population especially for rural population & can prevent epidemic diseases. Again there is no requirement of electricity or any other type of fuel for this process.

The present study is carried out to study the effect of water stored in *Tamra* vessel and Stainless Steel vessel with its changes in qualities .And for this study the comparator is stainless steel vessel which is most commonly in practice by Indian population all over in urban as well as rural area. Study is conducted in Village Kodoli , in district Kolhapur. In Kodoli local authority that is grampanchayat supplies purified water to people covered under its jurisdiction, in fact not daily. It is available alternate day or after every two days. This is an attempt to give better choice to above said population where there is need of two to three days storage of water.

AIM & OBJECTIVES

AIM:-

To study the comparison between changes in qualities of raw water stored in *Tamra* & Stainless Steel vessels.

OBJECTIVES:-

1. To study the changes in qualities of raw water stored in *Tamra* & Stainless Steel vessels respectively that is within sample.
2. To assess the qualities of raw water according to sources i.e. river & tube well.
3. To study the changes in raw water qualities according to six *rutu*.
4. To find out the ideal time duration for storage of raw water in above vessels to improve its qualities.

RESEARCH HYPOTHESES: -

1) **H_0 :** Water stored in *Tamra* vessel does not show significant changes in its qualities
   H_1 : Water stored in *Tamra* vessel shows significant changes in its qualities

2) **H_0:** Water stored in Stainless Steel vessel does not show significant changes in its qualities
   H_1: Water stored in Stainless Steel vessel shows significant changes in its qualities

3) **H_0:** Water stored in *Tamra* vessel does not show significant changes in its qualities than it stored in Stainless Steel vessel
   H_1: Water stored in *Tamra* vessel shows significant changes in its qualities than it stored in Stainless Steel vessel

REVIEW OF PREVIOUS WORK DONE

1Title – "A study on jala pradushana with special reference to jala shuddhikarana methods'' Water treatment by Katak Beej acoording to Sushruta Dissertation for M.D. by Dr. Ajit Patil at Dr.B.N.M.E.T's shri Mallikarjun Swamiji post graduate & research centre , Bijapur .

2 Title – " A clinical study of herbal purification of water by using seeds of plants in small scale." Dissertation for M.D. by Dr. B.S. Deshapande, at T.A.M. Pune under Poona University, Pune.

3 Title – " Strain specificity in antimicrobial activity of silver and copper nanoparticles" Research Paper published by Jayesh P. Ruparelia [a], Arup Kumar Chatterjee [c] , Sidhartha P. Duttagupta [b], Suparna Mukherji [a,] *

4 Title – "Storing drinking water in copper pot kills contaminating diarrhoeagenic Bacteria" Research Paper published by V. B. Preethi Sudha[1] , Sheeba Ganesan [1], G. P. Pazhani [2], T. Ramamurthy[2], G. B. Nair[2] and Padma Venkatasubramanian .

5 Title – "Analysis of water quality using physic chemical parameters tamdalge tank Kolhapur district , maharashtra." By S.A. Manjare, S. B. Thakare, S.A. Vhanalakar and D.V. Muley. Dept. of Zoology & Dept of Biotechnology , Shivaji University Kolhapur

6 Title - " Oligodynamic action of Silver, copper and Brass on enteric bacteria isolated from water of Kathmandu Vally" By Rajani Shrestha [1], Dev Raj Joshi[2], Jyosna Gopali [1], and Sujan Piya[3] [1]National College, Kathmandu.,[2]Central department of Microbiology, Tribhuvan university, Kathmandu, [3]College of Medicine, Chousn University 375,South Korea

7 Title – "Quality assessment of drinking water: A case study of Chandrapur District (M.S.)" by Pratiksha Tambekar, Pravin Morey, R. J. Batra and R. G. Weginwar from Rajiv Gandhi College of Engineering, Research and Technology, Babupeth, Chandrapur Research Article – Published in Journal of Chemical and Pharmaceutical Research, 2012, 4(5):2564-2570 ISSN : 0975-7384 CODEN(USA) : JCPRC5 2564

REVIEW OF LITERATURE

I] LITERATURE REVIEW OF *JALA* (WATER)

A) DESCRIPTION OF *JALA* (WATER) AYURVEDIC ASPECT

NIRUKTI OF *JALA*

Sushruta says, the material or the substance which is having *satva* and *tamo guna* is known as *jala* (*Su Sha* 1/27)

The substance or material which is having the properties *rupa, rasa and sparsha* is called as *jala* (*VD*)

Karikavali explains, the substance or material which is having the properties *shukla varna, sheeta sparsha, madhura rasa, sneha* and *sansidhik dravatrva* is called *jala*

The substance or material having *sheeta sparsha* is called *jala.* (*Tarkasangraha*)

UTAPPATI OF *JALA*

Rasa guna yukta jala originated from *agni*. (*Manu*)

Regarding origin of *jala in Taitariya Upanishad* they say, *Jala* is originated from the *agni*.

In Ramayan they mentioned sky draws water drops of the sea through sunrays stores them for nine months like a pregnant lady and in *Ashadha Masa* gives birth to beneficial rain.

SYNONYMS OF *JALA*

1) *Shabdakalpadruma*

Apa, Va, Vari, Salilum, Kamalum, Paya, Kilalum, Amrutum, Jivanum, Bhavanum, Vanum, Kavatvum, Udakum, Patha, Pushakarum, Sarvatomukhum, Ambha, Varna, Toyum, Paniyum, Nirum, Kshirum, Ambu, Sambarum, Meghapushpum, Ghanarasa, Santaclivoyum, Sarilum, Salum, Jadum, Kum, Anvum, Kapanvum, Udum, Dakum, Narum, Shambarum, Abhrapushpum, Ghritum, Pippalum, Kushum, Vishum, Kandum, Savarum, Sarum, Krupitum, Chandrorasum, Sadanum, Kavvurum, Vyoma, Samba, Sara, Ira, Vajum, Tamarum, Kambalum, Syandanum, Sambalum, Jalapiyum, Ksharu, Ritum, Vjjarm, Komalum, Somum,.

2) ***Bhavaprakash Nighantu***

पानीयं सलिलं नीरं कीलालं जलमम्बु च |
आपो वार्वारि कं तोयं पयः पाथस्तथोदकम् |
जीवनं वनमम्भोऽमृतं घनरसोऽपि च | भा.प्र.पू.ख्रं ६/१

Paaneeya, Salil, Nir, Kilal, Jal, Ambu, Ap, Var, Vari, Ka, Toya, Paya, Path, Udakum, Jivan, Van, Ambha, Arna, Amruta, Ghanarasa.

3) ***Madanpal Nighantu***

Paaneeya, Jivan, Nir, Kilal, Amrut, Jal, Ap, Ambha, Toya, Udaka, Path, Ambu, Salil, Pay.

VERNACULAR NAMES OF *JALA*

Hindi	-	Paanee, Jala
Bengali	-	Jala
Marathi	-	Panee
Gujarati	-	Pani
Kannada	-	Niru
Telagu	-	Nilu
Arebian	-	My
English	-	Water
Latin	-	Aqua

REFERENCES FROM THE *VEDAS:*

***Rugveda* (ऋग्वेद) :**

अप्स्वनतरमृतमप्सु भेषजम् | ऋ.१/२३/९

In the *Vedas* water has been described for its medicinal properties.

Jala is life and super medicine.

अप्सु मे सोमो अब्रविदन्तर्विश्वानि भेषजा | ऋ.१/२३/२०

Rudra has been described water as therapist.

In the *Rugveda* different types of water therapy has been described.

With water all the types of diseases can be treated.

आपो अद्यान्वचारिषं रसेन समुगस्माहि |

पयस्वानग्न आगहि तं मा संसृज वर्चसा | ऋ.१/२३/२३

Jala possesses *Agni Tatwa* which the body gets specific power (immunity).

शुचयाः पावकास्ता आपः देवीरिह मामवन्तु | ऋ.४/४९/२

Pure and holly water protects our body. *Jala* works as a defense against virus diseases.

रूद्रं जलाषभेषजम् | ऋ.१/४३/४

Rudra has been described as water therapist.

अप्सु अन्तः अमृतम् अप्सु भेषजमपामुत प्रशस्तये |

देवा भवत वाजिनः | ऋ.१/२३/१९

Jala has medicinal properties.

या आपो दिव्या उत वा स्त्रवान्ति खनित्रिमा उत वा या स्वयंजाः |

समुद्रार्था या शुचयः पावकास्ता आपो देवीरिह मामवन्तु | ऋ.७/४६/२

(Oh water) the water in which power / properties have been given by the King *Varun* some and all Gods in which *Vishwanar Agni* decides please protect me.

***Yajurveda* (यजुर्वेद) :**

प्रथमो दैव्यो भिषक् | यजु.१६/ ५

Rudra has been described as first divine physician.

वरूणं भिषजां पतिम् | यजु.२१/ ४०

Varun lord of water has been described as master of physicians and therapist.

***Atharvaveda* (अथर्ववेद) :**

जालाषमग्रभेषजं | अथर्व.६/ ५७ / २

Jala is a super medicine.

जीवा स्थ | अथर्व.१९/ ६९ / १

Jala is life.

इदमिद् वा भेषजमिदं रूद्रस्य भेषजम् |

येनेषुमेकतेजानाम् शतशल्यामपब्रवत् | अथर्व.६/ ५७ / १

This *jala* is a medicine which when given with lightning in *Rudra*'s medicine. This *jala* cures all types of wounds caused by arrows. *Jala* is poured around the wounds.

जालाषेणाभि पिश्च्यत जालाषेणोप सिश्च्यत |

जालाषमुग्रं भेषजं तेन नो मृड जीवसे | अथर्व.६/ ५७ / २

Jala is poured around the wounds. *Jala* is the one of the best drug for the burn wounds.

आपो..... हृदद्योत भेषजम् | अथर्व.६/ २४ / १

Jala cures hard diseases.

भिषग्भ्यो भिषक्तरा आपो | अथर्व.१९ / २ / ३

Water is most useful to physicians, the deep water being super and it is best tool for treatment.

अयक्ष्मंकरणिरपः | अथर्व.१९ / २ / ३

Jala destroys diseases and make life healthy.

REFERENCES FROM THE *PURANA*:

***Narada Purana* :**
Narada Purana has described importance of water. *Gang Jala* is superior in all. It cures all sins and diseases.

***Skanda Purana* :**
Skanda Purana has described importance of *Chaturmas Snan* [i.e. bath during *Chaturmas*] During *Chaturmas* God *Narayan* adopt in *Jala*

***Garuda Purana* :**
In *Garuda Purana* origin of water has described during the evolution of Nature.

REFERENCES OF *AVASTAS* (Forms) OF *JAJA*

REFERENCES FROM *DARSHAN GRANTH*

1) ***Ambha***

The *jala* which stays in upper part of S*uryamandal* that jala is called as *Ambha*. According to some *Acharyas* it is *Amrutsawrupa* (Nectar like) and place of *parmatma*.

2) *Marichi*

The *jala* which stays in between *suryamandal* and *purthvi* is called as *Mariachi*.

3) ***Mer***

The *jala* which stays on the surface of earth is called as *Mer*. Originated from combination of *Ambha* and *Marichi jala.*

4) Aap

The *jala* which stays below the surface level of earth is called *Aap*.eg. *Kupa Jala*

REFERENCES OF TYPES OF *JALA*

1) REFERENCES FROM *RIGVEDA* -

1) *Divya* 2) *Srtavanti* 3) *Swayanja* ऋ .7À49À2

2) REFERENCES FROM *ATHARVAVEDA* –

आपो धनत्याः अनूप्याः, खानित्रिमाः, वार्षिकीः | अथर्व.१/ ६ / ४

आपो हैमवतीः, उत्स्याः , सानिष्यदाः वर्ष्याः | अथर्व.१९/ २ / १

1. *Hemvati* - River water originated from Icy rocks.
2. *Atsya* - Fountain *Jala*.
3. *Sanishyada* - Water from flowing river.
4. *Varshya* - *Jala* from *Varshya rutu*.
5. *Dhanvanya* - *Jala* from Desert.
6. *Anupya* - *Anup deshaj jala*.
7. *Khanitrima* - Water which is diged out.
8. *Kumbhebhirabhruta* - Water kept in soil pot (*Ghat*).
9. *Anabhraya* - Water digs out without using hand or instrument.

3) REFERENCES FROM *TARKASANGRAHA*

Tarkasangraha mentioned mainly two types -

1*) Nitya -Paramanu rupa*

2) Anitya -Karya rupa

Anitya is also classified as three.

a)Sharir - The person who leave in *varun loka* having their body made up of *jala* and they are *ayonija.*

b) Indriya – Here we consider the *rasanendriya* i.e. *jaliya indiriya.*

c) *Vishya* - River, Tank, Kaupa, Him these are all the *vishya rupa* of *jala*.

4) REFERENCES FROM *BRUHATTRAYEE*

4 - A) REFERENCES FROM *CHARAKA SAMHITA* -

जलमेकविधं सर्व पतत्यैन्द्र नभस्तलात || च.सू.२७/१९६

Charaka says that, the entire water is ultimately of only one type viz, the one which falls from the sky as directed by *Indira.*

4– B) REFERENCES FROM *SUSHRUTA SAMHITA* –

Under classification of water ***Sushruta*** given basic two types -

1. *Aantariksha Jal*
2. *Bhaum Jal*

तत्रान्तरिक्षं चतुर्विधम्; तद्यथा धारं, कारं, तौषारं ,हैममिति |

तेषां धारं प्रधानं, लघुत्वात; तत् पुनर्द्विविधं गाग्ङ, सामुद्रं चेति || सु.सू.४५/ ७

Sushruta mentioned *antarikshya jala* (Atmosphere water) is of four types.

- *Dhara* –Water filling in torrents rain water.
- *Kara*- Water from melting of hailstones / ice clew.
- *Tausara*- Water from dew /mist.
- *Haima*- Water from melting of snow/ice.

Dhara is best because of its lightness. *Dhara* again classified as *Ganga* (atmospheric) and *Samudra* (terrestrial).

Ganga is rain water usually falling in *Asvayuja* month (mid sep-Oct).Both these should be put to test (as follow) rain water is collected in a silver vessel and a lump of boiled rice is immersed in it ,when examined after staying for a *Muhutra* (28 minitus) if the lump is seen not very moist and not changed in colour but remains as it was before then that water is to be understood *Ganga* (atmospheric water) if there appears a change of colour or the participles of the lump are highly moist (becoming slimy and very soft) than that water should be under stood as *Samudra* (terrestrial water) this should not be made use of even this *Samudra Jala* if collected in the month a of *Asvayuja* will be like *Ganga* (atmospheric rain water).

तस्यालभे भौमम् |तच्चाकाशगुणबहुलम् | तत् पुनः सप्तविधम् |

तद्यथा कौपं नादेयं सारसं ताडागं प्रास्त्रवणम् औभ्दिदं चौण्टयमिति || सु.सू.४५/ ७

This water is not available then *Bhauma Jala* (terrestrial ground water) which is predominant of qualities of *Aksha Bhuta* may be used that (*Bhuma Jala*) is of seven kinds -

1) *Kaupa* (tank with flight of steps)
2) *Nadeya* (river)
3) *Sarasa* (natural lake)
4) *Tadaga* (artificial lake)
5) *Prasravana* (waterfall)
6) *Udbhida* (natural spring)
7) *Caundya* (pit burrowed in the ground)

4 – C) REFERENCES FROM *ASHATANGA SANGRAHA* –

Vagbhatta has mentioned basic two types -

1. *Aantariksha Jal* (Rain Water)
2. *Bhaum Jal*

After testing its purity again he has divided rain water in two type's i.e.

1. *Ganga*
2. *Samudra*

येनाभिवृष्टममलं शाल्यन्नं राजतस्थितम् |

अक्लिन्नमविवर्णं वा तत्तोयं गाग्ङमन्यथा |

सामुद्रं तन्न पातव्यं मासादाश्वयुजाद्विना || अ.सं.सू.६ / ६

Good rain water collected in a clean silver vessel if poured over the cooked rice and allowed to stand for a few minutes should not alter the normal bright white colour of rice. This was the taste being carried out in olden days to determine the suitability of rain water for drinking .Water which did not stand this test was considered bad. All these kinds of water are called as *Samudra* (sea water) and should not be used for drinking except during *Asvayuja* month (mid of September) because of presence of the star '*Agastya'* (Conopus) which detoxicates poisons but not in other seasons.

Vagbhatta says that if rain water is not available then *Bhauma Jala* (terrestrial ground water) be used and is of **Eight types –**

कौप्यसारसताडागचौण्डयप्रास्त्रवणौभ्दिदम् |

वापीनदीतोयमिति तत् पुनः स्मृतमष्टधा || अ.सं.सू.६ / ११, १२

1) *Kupa* (Deep well)
2) *Sarasa* (Natural Tank)
3) *Tadaga* (Artificial Tank/Pond)
4) *Caunda* (Water collected in pits of rocks)
5) *Prasvana* (Flowing down from mountains)
6) *Audbhida* (Water from natural springs)
7) *Vapi* (Well with flights of steps all around)
8) *Nadi* (River)

4– D) REFERENCES FROM *ASHATANGA HRIDAYA*

गङाम्बु नभसो भ्रष्टं स्पृष्टं त्वकैन्दुमारूतैः|

हिताहितत्वे तभ्दूयो देशकालावपेक्षते ||

येनाभिवृष्टममलं शाल्यन्नं राजते स्थितम् |

अक्लिन्नमविवर्णं च तत्पेयं गागंम् ||

अन्यथा सामुद्रं तन्न पातव्यं मासादाश्वयुजाद्विना| अ.हृ.सू.५ / २३४

Only that rain water which makes the boiled rice kept in a clean silver plate neither too moist nor change its colour is to be considered as good for drinking.

All other kinds of water are called as *Samudra* (sea water) they should not be used for drinking except during *Asvayuja* (September – October / autumn season)

5) REFERENCES FROM *LAGHUTRAYEE*

5) – A) REFERENCES FROM *BHAVAPRAKASH*

पानीयं मुनिभिः प्रोक्तं दिव्यं भौममिति द्विधा ||

दिव्यं चतुर्विधं प्रोक्तं धाराजं करकाभवम् |

अतौषारज्ज तथा हैमं तेषु धारं गुणाधिकम्|| भा.प्र.पू.खं ६/३४

Water is said to be two types by seer. They are *Divya* (collected from sky) & *Bhauma* (availableon earth) Again *Divya jala* is classified into four types and they are *Dhara, Karakabhava, Tousara & Haima* out of which *Dhara jala* is considered the best.

धाराजलं च द्विविधं गाङ्गसामुद्रभेदतः ॥ भा.प्र.पू.खं ६/ ९

Dharajala is of two types and they are *Ganga* and *Samudra.*

BHAUMA JALA –

भौममम्भो निगदितं प्रथमं त्रिविधं बुधैः । जाङ्गलं परमानूपं ततः साधारणं क्रमात्॥ भा.प्र.पू.खं ६/२५

The water present on the earth is of three types and they are Jangala Anupa and Sadharana.

Bhauma Jala (terrestrial ground water) which is of twelve kinds -

1) *Nadey* (Water from river)
2) *Udbhida* (Water from springs)
3) *Nairzara* (Water from Streams)
4) *Sarasa* (Water from lake)
5) *Tadaga* (Water from Pond)

6) *Vapya* (Water from wide well)
7) *Kaupa* (Water from well)
8) *Caundya* (Water from pit burrowed in the ground)
9) *Palval* (water from small pond)
10) *Vikir* (Surface Water)
11) *Kaidara* (Water from fields)
12) *Vrushti* (Rain water collected from ground on same day)

6) REFERENCES FROM *NIGHANTU*

Madanapalnighantu says four types of *jala*

1) *Divya*
2) *Tusharaj*
3) *Dhar*
4) *Karihaim*

Divya is again divided into two types - a) *Ganga* & b) *Samudra*

REFERENCES OF PROPERTIES *OF JALA*

I. Properties Or Qualities Of *Antarikshajala* (Rain Water)
II. Properties Or Qualities Of *Gangambu Jala*
III. References Regarding Changing Properties Of *Jala*
IV. Properties Of Jala According To Geographical Conditions
V. Properties Of *Jala* According To *Desha*
VI. Properties Of *Nadeyajala* According To *Mahabhuta*
VII. Properties Of Nadeya Jala Originating From The Himalays
VIII. Properties Of *Jala*, According To *Shadarutu* (Season)
IX. The Properties Of *Bhauma Jala* (Terrestrial Ground Water)
X. Properties and Characteristics Of Good Potable Water
XI. Properties Of Dusta Jala (Contaminated Water) & Causes of water pollution

I) PROPERTIES OR QUALITIES OF *ANTARIKSHAJALA* (RAIN WATER)

1) REFERENCES FROM *PRASHASTAPADA*

Rupa, rasa, sparasha, dravatva, sneha, sankhya, pariman, pruthaktava, sanyoga, vibhaga, para, apartva, sanskar these are the 14 properties of *jala.*

2) REFERENCES FROM *BRUHATTRAYEE*

2) - A) REFERENCES FROM *CHARAKA SAMHITA*

शीतं शुचि शिवं मृष्टं विमलं लघु षडगुणम् |
प्रकृत्या दिव्यमुदकं भ्रष्टं पात्रमपेक्षते|| च.सू.२७/१९८
यदन्तरिक्षात् पततीन्द्रसृष्टं चोक्तैश्च पात्रैः परिगुह्यतेऽम्भः |
तदैन्द्रमित्येव वदन्ति धीरा नरेन्दपेयं सलिलं प्रधानम् || च.सू.२७/२०१
ईषत्कषायमधुरं सुसूक्ष्मं विशदं लघु |
अरूक्षमनभिष्यन्दि सर्वं पानीयमुत्तमम् || च.सू.२७/२०२

Charaka says that the rain water has by nature these six qualities - cold, pure, wholesome, palatable, clean and light. The water which falls from the sky, dropped by *Indra* and received in prescribed containers is said as '*Aindra*'(dropped by *Indra*) by the wise. It is the principal water drinkable for the Kings. Best water is slightly astringent – sweet, thin non slimy, light, non rough and non blocking of channels.

2) – B) REFERENCES FROM *SUSHRUTA SAMHITA*

तत्रान्तरिक्षं चतुर्विधम्; तद्यथा धारं, कारं, तौषारं ,हैममिति |
तेषां धारं प्रधानं, लघुत्वात; तत् पुनर्द्विविधं गाग्ङ, सामुद्रं चेति | सु.सू.४५/ ७

Antariksha Jala is of four types – *dhar , kar, taushar ,hema. Dhar* is prominent because of *laghu* (lightness) property; this again is of two types *ganga* and *samudra*.

पानीयमअन्तरिक्षमनिर्देशरसमृतं जीवनं तर्पणं धारणमाश्वासजननं |
श्रमक्लमपिपासामदमूर्च्छातन्द्रा निद्रादाहप्रशमनमेकान्ततः पथ्यतमंच || सु.सू.४५/ ३

Sushruta mentioned that water from *Aantariksha* (intermediate sphere between earth and sky) is of *Anirdishya rasa* (indistinct taste), *Amrutam* (nectar- like), *Jeevanam* (vitalizer), *Tarpanam* (satiating), *Dharanam* (sustaining), *Ashwasasjananam* (assuring) and relives *sharama* (fatigue and exhaustion), *Pipasa* (thirst), *Mada* (toxicity or narcosis), *Murcha* (fainting), *Tandra* (stupor or drowsiness), *Nidra* (sleepiness) and *Daha* (burning sensation) and is absolutely the *Pathyatam* (most wholesome or especially suitable for health)

3) REFERENCES FROM *LAGHURAYEE*

3) – A) REFERENCES FROM *BHAVAPRAKASHA*

धाराभिः पतितं तोयं गृहितं स्फीतवाससा| शिलायां वा सुधायां वा धौतायां पतितञ्चतत् ||
सौवर्णे राजसे ताम्रे स्फटिके काचनिर्मिते | भाजने मृन्मये वाऽपि स्थापितं धारमुच्यते ||
धारं नीरं त्रिदोषघ्नमनिर्देश्यरसं लघु| सौम्यं रसायनं बल्यं तर्पणं ह्रादि जीवनम् ||
पाचनं मतिकृन्मूर्च्छातन्द्रादाहश्रमक्लमान् | तृष्णां हरति तत् पथ्यं विशेषात्प्रावृषि स्मृतम् ||

भा.प्र.पू.खं ६/५६७८

He mentioned that water continuously flowing from the sky, collected from stone or earth filtered through a thick cloth and stored in a vessel made of gold, silver, copper, crystal, glass or earthen is known as *Dharajala.*

Dharajala pacifies all three *doshas* has got unmanifested taste , light to digest, pleasant , vitalizer, strengthening , satisfying, charming, life saving, digesting, make the brain function better , controls syncope, drowsiness , burning sensation, tiredness of motor and sensory organs and pacifies thirst. This water is particularly suitable during rainy / premonsoon season.

II) PROPERTIES OR QUALITIES OF *GANGAMBU JALA*

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *SUSHRUTA SAMHITA*

गगनाम्भु त्रिदोषघ्न गृहितं यत् सुभाजने |
बल्यं रसायनं मेध्यं पात्रापेक्षि ततः परम् || सु.सू.४५/ २६

Sushruta says that Rain water collected in a good vessel is *Tridoshaghna* (*tridosa* – alleviating) *balya* (strengthening), *Rasayana* and *Medhya* (intellect–promoting). Its merit increases in accordance with betterment of quality of the vessel.

1) – B) REFERENCES FROM *ASHTANG SANGRAH*

जीवनं तर्पणं हृद्यं हृादि बुद्धिप्रबोधनम् |तन्वव्यक्तरसं मृष्टं शीतं शुच्यमृतोपमम् || अ.सं.सू.६/२

सूर्योद्धृतप्रमुत्कत्वालघु वातकफापहम् |शैत्यजीवनसौम्यत्वैः पित्तरक्तविषार्जित् || अ.सं.सू.६/३

गङाम्बु नभसो भ्रष्टं स्पृष्टं त्वकैन्दुमारूतैः| हिताहितत्वे तत् भूयो देशकालावपेक्षते || अ.सं.सू.६/४

According to ***Vagbhatta*** the rain water is enlivening , satiating, pleasing to mind, refreshing, stimulating the mind, thin(*tanu*) not having any perceptible taste, sweet by nature, cool, clear nectar - like in property, easily digestible because it is first absorbed and later released by the sun, mitigating *vata* and *kapha*, curing disease of *pitta rakta* and *visha* (poison) by its cold, enlivening and coolant properties are the qualities of *Gangamhu* (rain water)which has fallen from the sky coming in contact with sunlight, moonlight and wind. It's good or Bad (suitability or un suitability) depends chiefly upon the region and season.

1) – C) REFERENCES FROM *ASHTANG HRIDAYA*

जीवनं तर्पणं हृद्यं हृादि बुद्धिप्रबोधनम् |तन्वव्यक्तरसं मृष्टं शीतं लघ्वमृतोपमम् || अ.हृ.सू.५ / १

गङाम्बु नभसो भ्रष्टं स्पृष्टं त्वकैन्दुमारूतैः |हिताहितत्वे तभ्दूयो देशकालावपेक्षते || अ.हृ.सू.५ / २

In ***Ashtang Hridaya*** the properties of *Gangambu* (rain water) which has fallen from the sky, coming in contact with sunlight ,moonlight and wind are enlivening , satiating , comforting (healthy) to the heart (mind), refreshing ,stimulating the intellect , thin , of imperceptible taste ,slightly sweet ,cold (coolant) , easily digestible , nectar like in property/effect . Its good or bad, depends chiefly on the region and season.

Gangambu is easily digestible after coming in contact with good sunlight or moonlight, but this water is not good suitable to health in all season of the year. It is good in *Sharad Ritu* (mid Sept to mid Nov) once rain water has fallen on the ground it acquires the properties of the land and becomes healthy or unhealthy depending. . It should be consumed within a few hours as it loses its properties by storing.

2) REFERENCES FROM *LAGHURAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASHA*

धाराजलं च व्दिविधं गाङ्गसामुद्रभेदतः ॥९॥

आकाशगङ्गासम्बन्धि जलमादाय दिग्गजाः। मेघैरन्तरिता वृष्टिं कुर्वन्तीति वचः सताम् ॥

गाङ्गमाश्वयुजे मासि प्रायो वर्षति वारिदः । सर्वथा तज्जलं ज्ञेयं तथैव चरके वचः ॥

स्थापिते हेमजे पात्रे राजते मृन्मये ऽपि वा ।शाल्यन्नं येन संसिक्तं भवेदक्लेदि वर्णवत् ॥

तद् गाङ्गं सर्वदोषघ्नं ज्ञेयं सामुद्रमन्यथा । तत्तु सक्षारलवणं शुक्रदृष्टिबलापहम् ॥

विस्त्रञ्च दोषलं तीक्ष्णं सर्वकर्मसु नो हितम् ।सामुद्रं त्वाश्विने मासि गुणैर्गाङ्गवदादिशेत् ॥ भा.प्र.पू.खं ६/१० ते १४

Dhara jala is of two types and they are *Ganga* and *Samudra.*

Person having pious character opine that, *diggaja* (mythical celestial elephants, which stand in the eight corners of the sky and support the earth) bring water from the *akasha Ganga* (a celestial river believed to be flowing in the sky) and make it flow through the clouds on to the earth.

The rain water which is collected during *Aswin* month (October) is supposed to be *Ganga jala. Caraka* too supports this fact. If rice is kept in this water in a vessel made of gold, silver or earthern, it does not get spoiled either in consistency or in colour. If some change occurs, the water is supposed to be *Samudram* (originated from sea). That water is slightly alkaline and salty and diminishes body strength, semen, and vision. It smells badly, enhances Dosas, penetrating and not advised for any purpose. But if *Samudrajala* rains in October that can be considered equal to *Ganga jala*.

III) REFERENCES REGARDING CHANGING PROPERTIES OF *JALA*

1) REFERENCES FROM *BRUHATTRAYEE*

1) - A) REFERENCES FROM CHARAK SAMHITA -

जलमेकविधं सर्वं पतत्यैन्द्र नभस्तलात ।तत् पतत् चैव देशकालावपेक्षते ॥

ख्रात् पतत् सोमवाय्वकैः स्पृष्टं कालानुवर्तिभिः । शीतोष्णस्निग्धरूक्षाद्यैर्यथासन्नं महीगुणैः ॥

च.सू.२७/१९६१९७

According to ***Charaka*** **e**ntire water is only one which falls down as rain from the sky .That while falling or having fallen down depend on place and time. Water while falling down from sky and coming in contact with the moon, the air and the sun which follow time, gets impregnated with the properties of cold, hot, unctuous, non unctuous etc and so when it rests on the ground .

1) – B) REFERENCES FROM *ASHTANG SANGRAH* & *HRIDAYA*

गङाम्बु नभसो भ्रष्टं स्पृष्टं त्वकैन्दुमारूतैः| हिताहितत्वे तत् भूयो देशकालावपेक्षते || अ.सं.सू.६/ ४

गङाम्बु नभसो भ्रष्टं स्पृष्टं त्वकैन्दुमारूतैः |हिताहितत्वे तभ्दूयो देशकालावपेक्षते || अ.ह.सू.५ / २

When rain water is falling it is the same everywhere. Only when it touches the earth then only it will acquire various properties and will be recognized as different types of waters. Not only have the properties of rain water changed according to the soil conditions. It will also acquire different properties when it is falling in different season (*rutu).* Therefore the properties of the falling rain water depend upon the *Desha, Kaal & Mahabhuta* (geological part , season & predominance of *mahabhuta*)

IV) PROPERTIES OF *JALA* ACCORDING TO GEOGRAPHICAL CONDITIONS

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *CHARAKA SAMHITA*

Acharyas described properties of rain water fallen on various types of soil or geographical condition in detailed and are as follows

कपिले क्षारसंसृष्टमूषरे लवणान्वितम् ||
कटु पर्वतविस्तारे मधुरं कृष्णमृत्तिके |
एतत् षाड्गुण्यमाख्यातं महीस्थस्य जलस्य हि || च.सू.२७/१९९२००

Charaka said that when the rain water falls on the earth its properties are dependent on the containing soil. It falls on the soil of white colour, becomes astringent in taste, on yellowish white soil it is bitter; on brown soil it is Alkaline soil it is of saline taste ;on the mountain valley it is pungent in taste and on the black soil it is sweet in taste. These are the six properties of the water positioned on earth. The water derived from rain, hailstone and snow has unmanifested *rasa* (taste).

1) – B) REFERENCES FROM *SUSHRUTA SAMHITA*

तत्र लोहितकपिलपाण्डुनीलपीतशुक्लेष्ववनिप्रदेशेषु
मधुरआम्ललवणकटुतिक्तकषायाणि यथासङ्यमुदकानि संभवन्ति || सु . सू . ४५/ ५

Sushruta says that rain water falling on the ground which is red , brown ,white ,yellowish white ,blue ,yellow and white (coloured soil) will be having tastes such as sweet ,sour ,salty , pungent ,bitter and astringent respectively .

1) – C) REFERENCES FROM *ASHTANG SANGRAH*

श्वेते कषायं तत्स्वादु कृष्णे तिक्तं च पाण्डुरे | नीले कषायमधुरं देशे लवणमूषरे ||
सक्षारं कपिले मिश्रं मिश्रेऽथाम्बुगुणाधिके | अ . सं . सू . ६ / ८- ९

According to ***Ashatanga sangraha*** water of the earth (terrestrial) from a place having white soil will be astringent in taste, in a place of black soil it will be sweet , in light yellowish soil it will be bitter ,in blue soil it is astringent - sweet ; in alkaline soil ,it will be salty ,in brown soil it will be alkaline, at place of mixed soil it will be mixed taste .

2) REFERENCES FROM *LAGHURAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASHA*

नदीसरस्तडागस्थे कूपप्रस्त्रवणादिजे । उदके देशभेदेन गुणान्दोषांश्च लक्षयेत् ॥ भा . प्र . पू . खं ६/ ३७

The properties of water from different sources like rivers, lakes, brooks, wells and streams can be assessed depending upon the region they flow.

V) PROPERTIES OF *JALA* ACCORDING TO *DESHA*

According to ***Ayurveda*** there are three regions explained *Anupa Desha, Jangla Desha* and *Sadharana Desha* & due to change in environment of these regions the qualities of water also are different in each region.

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *SUSHRUTA SAMHITA*

अनेकदोषमानूपं वार्यभिष्यन्दि गर्हितम् || सु.सू.४५/ ३७

Water from *Anupa Desha* (water from marshy regions) is *Anekadoshama* (contains many blemishes), *Abhishyandi* (increases moistness inside) and *Ahitama* (not suitable for health).

एभिर्दोषैरसंयुक्तं निरवद्यं तु जाङ्गलम् | सु.सू.४५/ ३८

Water from *Jangla Desha* (water from desert like regions) is free from the above bad qualities as so good for use.

पाकेऽविदाहि तृष्णाघ्नं प्रशस्तं प्रीतिवर्धनम् || सु.सू.४५/ ३८

दीपनं स्वादु शीतं च तोयं साधारणं लघु | सु.सू.४५/ ३९

Water from *Sadharana Desha* (temperate) region is *Avidahi* (does not cause burning sensation after digestion), *Trishnaghnam* (quenches thirst) , *prashastam* (suitable for drinking), *Preetivardhanam* (promotes happiness), *Deepanam* (kindles digestion), *Swadu* (sweet in taste), *Sheetam* (cold in potency) and *Laghu* (light).

1) – B) REFERENCES FROM *ASHTANG SANGRAH*

धन्वानूपमहीध्राणां सामीप्यात् गुरूलाघवम् | अ.सं.सू.६ / १५

The (easy or difficult) digestibility of water is dependent on its source being located near desert ,swamp or mountain regions .If the reservoir of water is in arid or desert region the water from that source is easily digestible, if the source is near mountains it is still more easily digestible, if the source is near swamps which are water logged always the water will be hard to digest .Digestibility was the criteria to decide the portability of water in ancient times in contrast to the present day criteria of hardness or softness .Soft water is easily digestible while hard water is hard to digest .

- *Jangala jala - Ruksha, lavana,lagdu, pittanashk, agnikaraka, kapha nashaka*
- *Anup Jala – Abhishyandi, madhura snigdha,* heavy, *kaphakarka*.
- *Sadharana jala – Madhura, agnipradepaka, sheetal*, light, *ruchikaraka* and *trishna, daha* and *tridoshnashaka.*

2) REFERENCES FROM *LAGHURAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASHA*

भौममम्भो निगदिंत प्रथमं त्रिविधं बुधैः | जाङ्गलं परमानूपं ततः साधारणं क्रमात् ||
अल्पोदकोऽल्पवृक्षश्च पित्तरक्तामयान्वितः | ज्ञातव्यो जाङ्गलो देशस्तत्रत्यं जाङ्गलं जलम् ||
बहम्बुर्बहुवृक्षश्च वातश्लेष्मायान्वितः | देशोऽनूप इति ख्यात आनूपं तध्दवं जलम् ||
मिश्रचिन्हस्तु यो देशः स हि साधारणः स्मृतः | तस्मिन्देशे यदुदकं तत्तु साधारणं स्मृतम् ||
जाङ्गलं सलिलं रूक्षं लवणं लघु पित्तनुत् |वह्निकृत्कफहृत्पय्यं विकारान्हरते बहून् ||
आनूपं वार्यभिष्यन्दि स्वादु स्निग्धं घनं गुरू | वह्निहत्कफकृद्वद्यं विकारान्कुरूते बहून ||
साधारणं तु मधुरं दीपनं शीतलं लघु | तर्पणं रोचनं तृष्णादाहदोषत्रयप्रणुत् ||

भा.प्र.पू.खं ६/२५ ते ३१

The water present on the earth is of three types and they are Jangala Anupa and Sadharana.

A region, where water and vegetation are scantily present and dominated by the diseases pitta and rakta is known as a Jangala and the water present there is known as Jangalajala.

A region, where water and vegetation are abundantly present and dominated by the diseases vata and kapha is known as aAnupa and the water present there is known as Anupajala.

A region, where characters of both are seen mingled is known as Sadharana and the water present there is known as Sadharanajala.

Jangalajala is drying salty in taste light to digest pacifies pitta enhances digestion diminishes kapha ideal to drink and cures many disease.

Anupajala blocks the channels inside, palatable, demulcent, concentrated, heavy, diminish digestive capacity, enhances kapha, cordial and causes many a disease.

SadharanaJala is sweet in taste, appetizer, cooling, light to digest, satisfying, increases the taste perception, and cures thirst, burning sensation and vitiation of Tridosa.

VI) PROPERTIES OF *NADEYAJALA* ACCORDING TO *MAHABHUTA*

Acharyas mentioned that the properties of rain water become changed due to predominance of *Panchamahabhuta* (Five Primary Elements) i.e. *Prthvi, Ap, Teja, Vayu* and *Aksha* in detailed and are as follows –

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *SUSHRUTA SAMHITA*

पृथिव्यादीनामन्योन्यानुप्रवेशकृतः सलिलरसो भवत्युत्कर्षापकर्षेण |
तत्र, स्वलक्षणभूयिष्ठायां भूमावम्लं लवणं च ; अम्बुगुणभूयिष्ठायां मधुरं;
तेजोगुणभूयिष्ठायां कटुकं तिक्तं च; वायुगुणभुयिष्ठायां कषायम;
आकाशगुणभुयिष्ठायामव्यक्तरसम् , अव्यक्तं ह्याकाशमित्यतः ;
तत् प्रधानमव्यक्तरसत्वात् ,तत्पेयमान्तरीक्षालाभे || सु.सू.४५/ ६

Tastes of water become either prominent (well manifest) or not prominent (poorly manifest) from predominance of specific elements; due to intermingling of *Prthvi* etc ;(five primary elements) such as for eg. taste of water fallen on the ground which is predominant of its own *Prathvi Bhuta* will be sour and salty , that fallen on the ground which is predominant of *Ap Bhuta* will be sweet ,that fallen on the ground predominate of *Teja Bhuta* will be pungent and

bitter, that fallen on the ground predominate of *Vayu Bhuta* will be astringent ,that fallen on the ground predominant of *Aksha Bhutta* will be unmanifest in taste; since *Aksha Bhuta* is itself unmanifest ,the taste of water will also be prominently unmanifest (has very weak taste or tasteless) ,this kind of water may be consumed in the absence of rain water.

1) – B) REFERENCES FROM *ASHTANG SANGRAH*

.....अम्बुगुणाधिके मधुरं लवणाम्लं तु भवेत्भूमिगुणाधिके ||
तेजोधिके तिक्तकटु कषायं पवनाधिके |
दिव्यानुकारि त्वव्यक्तरसत्वात् खगुणाधिके ||
शुचिपृथ्वसितश्वेते देशे चार्कानिलाहतम् | अ.सं.सू.६ / ९ – १०

According to***Ashtang Sangraha*** if the region of the land is the qualities of *Ap bhuta* predominately the rain water of that region will be sweet. If the region is predominantly in the qualities of *Pruthvi bhuta* the water will be salty and sour. In region which is predominantly *Tejasa* the water will be bitter and pungent. In regions predominant of qualities of *Vayu bhuta* the water will be astringent. In regions which posses the qualities of *Akasha bhuta* predominantly the water will be tasteless and resembles rain water in all respects. The water from a clean place having black or white soil and fully exposed to sun light and wind is also similar to rain water.

VII) PROPERTIES OF *NADEYA JALA* ORIGINATING FROM THE *HIMALAYS*

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *CHARAK SAMHITA*

नद्यः पाषाणविच्छिन्नविक्षुब्धाभिहतोदकाः |हिमवत्पभवाः पथ्याः पुण्या देवर्षिसेविताः || च.सू.२७/२०९

The rivers originated from Himalayas and constantly used by the sages and having water obstructed, agitated and beaten are wholesome and virtuous.

नद्यः पाषाणसिकतावहिन्यो विमलोदकाः |मलयप्रभवा याश्च जलं तास्वमृतोमम् || च . सू . २७/२१0

Those originating from Malaya, carrying stones and sand have clean water which is like nectar.

पश्चिमाभिमुखा याश्च पथ्यास्ता निर्मलोदकाः | प्रायो मृदुवहा गुर्व्यो याश्च पूर्वसमुद्रगाः || च . सू . २७/२११

The rivers flowing towards west have clean water and are wholesome while those joining the eastern sea are mostly mild flowing and heavy.

पारियात्रभवा याश्च विन्ध्यसह्यभवाश्च याः | शिरोहृद्रोगकुष्ठानां ता हेतुः श्लीपदस्य च || च . सू . २७/२१२

Water of the rivers originating from *Pariyatra, Vindhya* and *Sahya* cause head diseases, heart disease, leprosy and filaria.

1) – B) REFERENCES FROM *SUSHRUTA* –

तत्र नद्यः पश्चिमाभिमुखाः पथ्याः , लघूदकत्वात् पूर्वाभिमुखास्तु न प्रशस्यन्ते ,

गुरूदकत्वात् दक्षिणाभिमुखा नातिदोषलाः , साधारणत्वात् | सु . सू . ४५/ २१

Water of rivers which flow westward is healthy because of lightness(easily digestible) that of rivers flowing eastward is not ideal because of heaviness (hard for digestion)of river flowing southward do not increase the *Doshas* greatly ,because of moderateness.

तत्र सह्यप्रभवाः कुष्ठं जनयन्ति , विन्ध्यप्रभवाः कुष्ठं पाण्डुरोगं च,

मलयप्रभवाः कृमिन् महेन्द्रप्रभवाः श्लीपदोदराणि,

हिमवत्प्रभवा हृद्रोगश्वयथुशिरोरोग श्लीपदगलगण्डान् सु . सू . ४५/ २१

Water of rivers arising from *Sahya* (Southern branch of western ghat) produce leprosy, of those arising from *Mahendra* mountains (Northern range of Western ghat) produce filariasis and abdominal enlargements; of those arising from *Himvat* (Himalaya) mountain produce heart disease, dropsy, disease of the head, filiariasis and goiter.

प्राच्यावन्त्या अपरावन्त्याश्चार्शस्युपजनयन्ति ,

पारियात्रप्रभवाः पथ्या बलारोग्यकर्य इति || सु . सू . ४५/ २१

Water of rivers of provinces such as *Prachya* (central Bengal and North Orrisa) Avanti (round about city of Ujjain)and *Aparvantya (*Kokan) produce haemorrhoids; of the *Pariyatra* (Western ranges of Vindhya mountains) are healthy, bestow strength and health.

नद्यः शीघ्रवहा लघ्व्यः प्रोक्ता याश्चामलेदकाः |

गुर्व्यः शैवालसंछन्नाः कलुषा मन्दगाश्च याः || सु.सू.४५/ २२

Water of swift flowing river and which is clear is said to be light, while that of rivers slow, covered with algae and dirt is said to be heavy (not easily digestible)

प्रायेण नद्यो मरूषु सतिक्ता लवणान्विताः |

लघ्व्यः समधुराश्चैव पौरूषेया बले हिताः || सु.सू.४५/ २३

Generally, water of rivers of desert regions will be slightly bitter mixed with salt in taste, light slightly sweet, aphrodisiac and good for strength.

1) – C) REFERENCES FROM *ASHTANG SANGRAHA* -

पश्चिमोदधिगाः शीघ्रवहा याश्चामलोदकाः || अ.सं.सू.६ / १५

पथ्या समासात्ता नद्यो विपरीतास्ततोऽन्यथा | अ.सं.सू.६ / १६

Rivers which flow into the western sea, are swift and have clean water, such water is good for health; those of the opposite direction (eastern) are opposite in qualities also, hence not good for health.

उपलास्फालनाक्षेपविच्छेदैः खेदितोदकाः || अ.सं.सू.६ / १६

हिमवन्मलयोद्भूताः पथ्यास्ता एव च स्थिताः |

किमिश्लीपदहृत्कण्ठशिरोरोगान् प्रकुर्वते || अ.सं.सू.६ / १७

Water from rivers arising from the Himalaya and Malaya mountains (western ghats of Karnataka and Kerala states) undergoing constant swirling, lashing against rocks, falling from height and dispersed into minute drops etc. will also be good for health; the same water (river water) stagnated for long is not and good will produce parasitic disease filariasis disease of the heart, throat and head.

प्राच्यावन्त्यपरान्तोत्था दुर्नामानि महेन्द्रजाः |

उदरश्लीपदातङान् सह्यविन्ध्यभवाः पुनः ||

कुष्ठपाण्डुशिरोरोगान् दोषघ्न्यः पारियात्रजाः |

बलपौरूषकारिण्यः सागराम्भस्त्रिदोषकृत् || अ.सं.सू.६ / १८१९

Water of rivers of the countries such as *Prachya , Avanti , Aparanta* and those arising in *Mahendra* mountains produces disease like piles ,enlargement of abdomen and filiriasis; water of rivers arising from Sahya and Vindhya mountains produce leprosy (and other skin disease s) anemia and disease of the head ; rivers arising from *Pariyatraja* mountains mitigates all the *doshas*, improve strength and velour ; water from the sea tend to increase all the three *doshas*.

1) – D) REFERENCES FROM *ASHTANG HRIDAYA*-

पश्चिमोदधिगाः शीघ्रवहा याश्चामलोदकाः ||

पथ्या समासात्ता नद्यो विपरीतास्ततोऽन्यथा | अ.ह.सू.५ / ९९

The water of the rivers which flow into the western ocean (Arabian sea) which are swift and which have pure water (uncontaminated) is good for health where as it is opposite (bad for health) if it is otherwise.

उपलास्फालनाक्षेपविच्छेदैः खेदितोदकाः ||

हिमवन्मलयोभ्दताः पथ्यास्ता एव च स्थिराः |

कृमिश्लीपदहृत्कण्ठशिरोरोगान् प्रकुर्वते || अ.ह.सू.५ /९ १0

The water of rivers arising from the Himalaya and Malaya mountains and which get churned up well by dashing against rocks are good for health, whereas the same water if gets stagnated (and gets contaminated) gives rise to worms (Intestinal parasites) , filariasis , disease of the heart, throat and head .

प्राच्यावन्त्यपरान्तोत्था दुर्नामानि महेन्द्रजाः |

उदरश्लोपदातङान् सह्यविन्ध्योभ्दवाः पुनः ||

कुष्ठपाण्डुशिरोरोगान् दोषघ्न्याः पारियात्रजाः |

वलपौरूषकारिण्यः सागराम्भस्त्रिदोषकृत् || अ.हृ.सू.५ / १११२

Water of rivers of the *Prachya* (gauda) , *Avanti* (malwa), *Aparanta* (Konkana) countries produces piles (haemorrhoids) ; of those arising from *Mahendra* mountains cause enlargement of abdomen and filiriasis; those arising from Sahya and Vindhya mountains produces leprosy (and other skin disease s) anemia and disease of the head ; of those arising from *Pariyatraja* mountains mitigates the(aggravated) *doshas*, bestow strength and sexual vigor ; the water of the sea causes vitiation of all the three *doshas*.

2) REFERENCES FROM *LAGHURAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASHA*

हिमवत्प्रभवाः पथ्या नद्योऽश्माहतपाथसः । गङ्गाशतद्रुसरयूयमुनाऽऽद्या गुणोत्तमाः ॥

सह्यशैलभवा नद्यो वेरागोदावरीमुखाः । कुर्वन्ति प्रायशः कुष्ठमीषव्दातकफावहाः ॥

भा.प्र.पू.खं ६/३५३६

The water from the rivers, which originate at Himalayan rangesis good & ideal or from those rivers which run on mountainous hillocks and the examples are *Ganga, Satadru, Saruyu, Yamuna* etc. Water from rivers originating in *sahya* mountains (western ghats) like *Krishna* and *Godavari* may cause skin diseases and aggravate *Vata* and *Kapha*.

VIII) PROPERTIES OF *JALA* ACCORDING TO *SHADARUTU* (SEASON)

According to Ayurveda every two consecutive months starting with *Margasiras* constitute the six *Rutus* (seasons) that are; *Hemant, Shishir, Vasant, Grishma, Varsha & Sharad*. Amongst them the period of three seasons from *Shishira* to *Grishma* is known as *Aadan Kala* or *Uttarayana* (receiving) and the period of three seasons from *Varsha* to *Hemanta* is known as *Visarga Kala* or *Dakshinayana* (releasing).

KAALGANANA

Kaal	*Ayana*	*Rutu*	*Charak , Sushruta & Yogaratnakar*	*Vagbhata*	*Sadya Bharatiya*	English *Kaal Ganana*
Visrgak aal	*Dakshin Ayana*	*Varsha*	*Shravana, Bhadrapada*	*Aashadha, Shravana*	*Jyashtha , Aashadha*	June (*Uttarardha*), July , August (*Purvardha*)
		Sharada	*Ashwin, Kartik*	*Bhadrapada, Ashwin*	*Shravana, Bhadrapada*	August (*Uttarardha*), Sept, Oct (*Purvardha*)
		Hemanta	*Margashirsha, Pausha*	*Kartik, Margashirsha*	*Ashwin, Kartik*	Oct (*Uttarardha*), Nov , Dec (*Purvardha*)
Aadana kaal	*Uttar Ayana*	*Shishira*	*Magha, Falguna*	*Pausha, Magha*	*Margashirsha, Pausha*	Dec (*Uttarardha*), Jan , Feb (*Purvardha*)
		Vasanta	*Chaitra, Vaishakha*	*Falguna, Chaitra*	*Magha, Falguna*	Feb (*Uttarardha*), March , April (*Purvardha*)
		Grishma	*Jyashtha , Aashadha*	*Vaishakha, Jyashtha*	*Chaitra, Vaishakha*	April (*Uttarardha*), May, June (*Purvardha*)

It is interesting to note the properties and characteristics of water according season (*rutu*). The original description of this fact is as follows.

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *SUSHRUTA SAMHITA:*

तत्र वर्षास्वान्तरिक्षमौभ्दिदं वा सेवेत महागुणत्वात् ; शरदि सर्वं प्रसन्नत्वात् ; हेमन्ते सारसं ताडागं वा; वसन्ते कौपं प्रास्त्रवणं वा; ग्रीष्मेऽप्येवं ; प्रावृषि चौण्टयमनभिवृष्टं सर्वं चेति || सु.सू.४५/ ८

Sushruta mentioned that during *Varsha Rutu* (rainy season) atmospheric water (rain water) or water from springs may be used, because of their profound good qualities .During *Sharad Rutu* (autumn) all kinds of water may be used, because of being clear. (free from contaminates) During *Hemanta Rutu* (dewy winter) water of either natural lake or artificial lake (tank) may be used. During *Vasanta Rutu* (spring season) water of artificial tank or a spring maybe used. In *Grishma Rutu* (summer) also in the same manner. (same kind of water) During *Pravat* (early rainy season) water collected in burrows and all other kinds which are not from rain may be used.

1) – B) REFERENCES FROM *CHARAK SAMHITA*:

1) Hemanta :

हेमन्त सलिलं स्निग्धं वृष्यं बलहितं गुरू | च . सू . २७/२0५

The properties of Water available during the *Hemant rutu* (Early winter) is *Snigdha*(unctuous), *Vrushya* (aphrodisiac) , *Balahitam* (strength promoting)and *Guru* (heavy)

2) *Shishir* :

किंचित्ततो लघुतरम शिशीरे कफवातजित || च . सू . २७/२0५

That of the *Shishira rutu* (later part of Winter) is *laghutar (*slightly lighter) and *kapha vata jeeta* (alleviator of *Kapha* and *Vata*).

3) *Vasanta* :

कषायमधुरं रूक्षं विद्याद्वासन्तिकं जलम् | च . सू . २७/२0६

Water available during *Vasanta rutu* (spring) is *Kashaya* (astringent), *Madhura* (sweet in taste) and *Ruksha*. (unctuous)

4) *Grishma* :

ग्रैष्मिकं त्वनभिष्यन्दि जलमित्येव निश्चयः | च . सू . २७/२0६

The properties of Rain water in *Grishma rutu* is *Anabhishandhi* and it is not *kapha karak.* Water of summer season is not greasy.

5) *Varsha :*

गुर्वाभिष्यन्दि पानीयं वार्षिकं मधुरं नवम् || च . सू . २७/२0३

The properties of Rain water in *Varsha rutu* (rainy season) is *Madhur* (sweet), *Guru* (heavy in digestion) and *Abhishandhi* (blocking of channels).

6) *Sharada* :

तनुलघ्वनाभिष्यन्दि प्रायः शरदि वर्षति || च . सू . २७/२0३

तत्तु ये सुकुमाराः स्युः स्निग्धभूयिष्ठभोजनाः |

तेषां भोज्ये च भक्ष्ये च लेह्ये पेये च शस्यते || च . सू . २७/२0४

The properties of Rain water in *Sharada rutu* (autumn) is *Tanu* (thin), *Laghu* (light), *Anabhishandhi* (non blocking of channels) and This should be used by the *Sukumar* persons (persons with tender bodily constitution and those who are accustomed to taking predominantly unctuous food) are advised to use this water in the preparation of *bhojan* (eatable), *bhakshan* (chewable), *Lehan* (likeable) and *Peyan* (drinkable) .

ऋतावृताविहाख्याताः सर्व एवाम्भसो गुणाः || च . सू . २७/२0६

Thus the properties of various types of water in different seasons have been described. Water collected from untimely rains is undoubtedly unwholesome.

1) – C) REFERENCES FROM ASHTANG SANGRAH & HRIDAYA -

Both ***Vagbhatas*** are given very short description about *jala* according to *rutu* and is as follows –

दिव्यं वारि वरं वर्षे नादेयंवरं परम् | अ . सं . सू . ६ / ५१

Rain water is the best (ideal drinking), during *Varsha rutu* (rainy season) where as river water is not good (during that season).

वर्षासु दिव्यनाद्धेये परं तोये वरावरे | अ . ह्र . सू . ५ / २0

During *Varsha rutu* (rainy season) rain water is the best and river water least (in their qualities and fitness for drinking).

2) REFERENCES FROM *LAGHUTRAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASHA*

हेमन्ते सारसं तोयं तडागं वा हितं स्मृतम् | हेमन्ते विहितं तोयं शिशिरेऽपि प्रशस्यते ||

वसन्तग्रीष्मयोः कौपं वाप्यं वा नैर्झरं जलम् | नादेयं वारि नादेयं वसन्तग्रीष्मयोर्बुधैः ||

विषवद्वनवृक्षाणां पत्राद्यैर्दूषितं यतः |

औभ्दिदं वाऽन्तरिक्षं वा कौपं वा प्रावृषि स्मृतम् | शस्तं शरदि नादेयं नीरमंशूदकं परम् ||

भा . प्र . पू . ख्रं ६/५९ ६0 ६१

During winter, water from a lake or pond is ideal to use, the same is with antumn and during spring and summer from a well, a large well or from a stream. During spring and summer, wisemen should not use water from a river because during that period, it is contaminated by leaves etc, from poisonous plants. Hence water from springs, rain or wells is advised at that time. During post monsoon period, water from rivers or *Amshudaka* is advised.

शरदि स्वच्छमुदयादगस्त्यस्याखिलं हितम् || भा.प्र.पू.खं ६/६४

During post monsoon period, all types of water are clear and ideal to use because of the rising of star *Agastya*.

पौषे वारिसरोजातं माघे तत्तु तडागजम् | फाल्गुने कूपसम्भूतं चैत्रे चौण्डयं हितं मतम् ||

वैशाखे नैर्झरं नीरं ज्येष्ठे शस्तं तथौध्दिदम् | आषाढे शस्यते कौपं श्रावणे दिव्यमेव च ||

भाद्रे कौपं पयःशस्तमाश्विने चौण्डयमेव च | कार्त्तिके मार्गशीर्षे च जलमात्रं प्रशस्यते ||

भा.प्र.पू.खं ६/६५६६६७

During *Paushya* water from a lake, in *Magha* from a pond, in *Phalguna* from a well, during *Chaitra* from a pit, during *Vaishakha* from a stream, during *Jyestha* from a spring, during *Ashadha* well Water, during *Shravana* rain water, during *Bhadrapada* well water, during *Ashvin* from a pit and during *Kartika* and *Margashirsh* water from any source are ideal to consume.

THE PROPERTIES OF *HANSODAKA* -

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *CHARAK SAMHITA* –

दिवा सूर्याशुसंतप्तं निशि चन्द्रांशुशीतलम् | कालेन पक्वं निर्दोषमगस्त्येनाविषीकृतम् ||

हंसोदकमिति ख्यातं शारदं विमलं शुचि | खानपानावगाहेषु शस्यते तद्यथाऽतम् || च.सू.६/४६ – ४७

The water heated with sunrays during day and cooled with moonrays during night , cooked by time , free from defects and detoxicated by agastya (a star) is known as Hansodaka , which is obtained during autumn and is clean & pure.This water is beneficial like nectar if it used in bath , drink and plunging .

1) – B) REFERENCES FROM *ASHTANG SAMGRAH* –

दिवा दिवाकरकरैर्निशाकरकरैर्नीशि | सन्तप्तं ह्रादितं तोयमगस्त्येनाविषीकृतम् ||

निर्मलं शुचि कालेन पक्वं पानेऽमृतोपमम् | हंसौघपक्षविक्षेपभ्रमद्भ्रमरपंक्तिषु || अ . सं . सू . ४/५६ – ५७

The water made warm by sunrays in the afternoons and cooled by moonlight at nights, and which is pleasant (clean), removed of poisonous effect by the rising of Agastya constellation such pure, clear water, cooked by time is an ideal as nectar itself for drinking in this season.

1) – C) REFERENCES FROM *ASHTANG HRIDAYA*–

तप्तं तप्तांशुकिरणैः शीतं शीतांशुरश्मिभिः | समन्तादप्यहोरात्रमगस्त्योदयनिर्विषम् ||

शुचि हंसोदकं नाम निर्मल मलजिज्जलम् | नाभिष्यन्दि न वा रूक्षं पानादिष्वमृतोपमम् ||

अ . ह्र . सू . ३/५१५२५३

The water which gets heated by the hot rays of sun during day and gets cooled by the cool rays of moon during night , for many days continuously ,which has been de-poisoned (detoxicated) by the rise of star Aagastya, which is pure, uncontaminated and capable of mitigating the malas (doshas) is known as Hansodaka. It is neither Abhishyandi (producing more secretions or moisture inside the minute channels so as to block them) nor dry (causing dryness or non-production of sufficient moistness in the channels). This water is like amruta (nector) for drinking and other purpose.

2) REFERENCES FROM *LAGHUTRAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASH* –

यतोऽगस्त्यस्य दिव्यर्षेरूदयात्सकलं जलम् | निर्मलं निर्विषं स्वादु शुकलं स्याददोषलम् ||

भा . प्र . पू . ख्रं ६/१५

The reason of purity of rain water during the month of October is that, star *Agastya* who appears in the sky makes the water free from any type of poisons; this water is clear, palatable, enhances *Sukra* (semen) and doesn't aggravate *Doshas*.

.....शस्तं शरदि नादेयं नीरमंशूदकं परम् ||

दिवा रविकरैर्जुष्टं निशि शीतकरांशुभि:| ज्ञेयमंशूदकं नाम स्निग्धं दोषत्रयापहम् ||

अनभिष्यन्दि निर्दोषञ्चान्तरिक्षजलोपमम् | बल्यं रसायनं मेध्यं शीतं लघु सुधासमम् ||

भा.प्र.पू.ख्रं ६/६१ ६२ ६३

REFERENCES FROM *YOGARTNAKAR* –

दिवा रविकरैर्जुष्टं निशि शीतकरांशुभि: | ज्ञेयमंशूदकं नाम स्निग्धं दोषत्रयापहम् ||

योगरत्नाकर ऋतुचर्या शरद ऋतु ३

In post monsoon period rain water or *Anshudaka* (water which comes in contact with the direct rays of sun and moon) is ideal. This water is demulcent and pacifies *doshas*. It is equal to rain water, strength giving, vitalizer, brain tonic, cooling, easy to digest and similar to divine nectar.

IX) THE PROPERTIES OF *BHAUMA JALA* (Terrestrial Ground Water)

In the rainy season the water gets admixed with soil, worms, snakes, rats and their excreta. This joins the river water. This in turn contaminates the river water. Therefore in rainy season especially it is not good health. This water will increase the tri *doshas*.

If the water of *Kupa* is sweet is in nature then it acts as a *tridosha nashaka*, good for health and light one but if it is salty in nature acts as a *kapha vata nashaka*, *agnipradepaka*, but more *pittakarka.*

The water of *tadaka* is *madhura* and *kashyaya* taste and *katu paki* acts as *vatakaraka* and *pitta, kapha nashak.*

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *SUSHRUTA SAMHITA*-

Qualities of *Nadeya Jala* :

नादेयं वातलं रूक्षं दीपनं लघु लेखनम्

तदभिष्यन्दि मधुरं सान्द्रं गुरू कफावहम् || सु.सू.४५/ ३१

Water of rivers is *Vatala* (increases vata), *Ruksha* (dry), *Deepanam* (stimulates digestive power), *Laghu* (light) and *Lekhanam* (reduces body weight). If the same, however, is *Madhur* (sweet) *Sandra* (thick), *Guru* (heavy or hard for digestion) *Abhishandi* (increases mucus secretion) and *Kaphavaham* (aggravates *Kapha*).

Qualities of *Saras Jala* :

तृष्णाघ्नं सारसं बल्यं कषायं मधुरं लघु | सु.सू.४५/ ३२

Water of *Saras* i.e. natural lakes is *Trushanaghna* (mitigates thirst), *Balya* (strengthening)\
Madhur (sweet), *Laghu* (light), *Kashaya* (astringent).

Qualities of *Tadag Jala* :

ताडागं वातलं स्वादु कषायं कटुपाकि च || सु.सू.४५/ ३२

Water of *Tadaga* (tank) is *Vatala* (increases *Vata)*, *Swadu* (sweet), *Kashaya* (astringent) and *Katupaki* (become pungent after digestion).

Qualities of *Vapya Jala* :

वातश्लेष्महरं वाप्यं सक्षारं कटुपित्तलम् | सु.सू.४५/ ३३

Water of *Vapi* (well) is *Vatashleshmahar* (mitigates *Vata* and *Kapha)*, *Sa-ksharam* (alkaline), *Katu* (pungent) and *Pittalam* (*pitta*- increasing).

Qualities of *Kaupa Jala* :

सक्षारं पित्तलं कौपं श्लेष्मघ्नं दीपनं लघु || सु.सू.४५/ ३३

Water of *Kupa* (deep well) is *Sa-ksharam* (alkaline), *Pittalam* (*pitta*- increasing), *Shleshmaghana* (mitigates *kapha*), *Deepanam* (appetizer) and *Laghu* (light).

Qualities of *Chaundya Jala* :

चौण्डयमग्निकरं रूक्षं मधुरं कफकृन्न च | सु.सू.४५/ ३४

Water of *Cunti* (pits burrows) is *Agnikaram* (stimulates digestion), *Ruksha* (dry), *Madhuram* (sweet) and *Kapha krunna* (does not increase *Kapha*)

Qualities of *Prasravanodbhava Jala* :

कफघ्नं दीपनं हृद्यं लघु प्रस्त्रवणोभ्दवम् | सु.सू.४५/ ३४

Water from *Prasravana* (streams) is *Kaphaghnam* (mitigates *Kapha*), *Deepanam* (stimulates *agni*), *Hrudya* (agreeable or good for heart) and *Laghu* (light).

Qualities of *Audbhida Jala :*

मधुरं पित्तशमनमविदाह्यौभ्ददं स्मृतम् || सु.सू.४५/ ३५

Water of *Audbhida* is *Madhuram* (sweet), *Pitta Shamak* (*Pitta*- pacifying) and *Avidhayi* (does not create heartburn).

Qualities of *Vaikira Jala* :

वैकिरं कटु सक्षारं श्लेष्मघ्नं लघु दीपनम् | सु.सू.४५/ ३५

The water of *Vaikira* (oozing from the ground) is *Katu* (pungent), *Sa-ksharam* (alkaline), *Shleshmaghana* (*Kapha* – allevating), *Laghu* (light) and *Deepanam* (stimulate *agni*).

Qualities of *Kedar Jala* :

कैदारं मधुरं प्रोक्तं विपाके गुरू दोषलम् || सु.सू.४५/ ३६

Water from *Kedara* (fiels) is *Madhur* (sweet after digestion), *Guru* (heavy) and *Doshalam* (vitiates all the *doshas*).

Qualities of *Palval Jala* :

तव्दत्पाल्वलमुद्दिष्टं विशेषाद्दोषलं तु तत् || सु.सू.४५/ ३६

The water of *Palvala* (marshy region) is similar, particularly *Doshalam* (aggravates the *doshas*).

Qualities of *Samudra Jala :*

सामुद्रमुदकं विस्त्रं लवणं सर्वदोषकृत् || सु.सू.४५/ ३७

Water from the *Samudra* (sea) is *Visaram* (having fishy smell), *Lavanam* (salty), and *Sarva-doshkrut* (vitiates all *doshas*).

1) - B) REFERENCES FROM *ASHATANG SANGRAH-*

सक्षारं पित्तकृत् कौपं दीपनान्नातिवातलम् || अ.सं.सू.६ / १२

सारसं स्वादु लघु च ताटाकं गुरू वातलम् |

चौण्डं तु पित्तलं दोषहरं प्रास्त्रवणोदकम् || अ.सं.सू.६ / १३

औभ्दिदं स्वादु पित्तघ्नं स्वादु वापीजलं लघु |

नादेयं वातलं रूक्षं कटुकं च तदादिशेत् || अ.सं.सू.६ / १४

Kaupa – The water from deep well is a alkaline and increase *Pitta*

Sarasa – Water from natural lakes improves digestion, does not increase *Vata* greatly (but may make for its mild increase) is sweet in taste and easily digestible.

Tadaga – Water of artificial ponds or tanks is hard to digest and increases *Vata*

Caunda – Water from pits in rocks increase *Pitta*

Prasravanodaka – Water flowing down the mountains mitigates all the *Tridoshas*

Audbhida – Water from springs, is sweet and mitigates *Pitta*

Vapi jala – Water from well with fight of steps is sweet and easily digestible

Nadeya – Water from rivers increase *Vata*, is dry (non- greasy) and pungent.

2) REFERENCES FROM *LAGHUTRAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASH* –

Qualities of *Nadeya Jala* :

नादेयमुदकं रूक्षं वातलं लघु दीपनम् | अनभिष्यन्दि विशदं कटुकं कफपित्तनुत ||

नद्यः शीघ्रवहा लघ्व्यः सर्वा याश्चामलोदकाः | गुर्व्यः शैवलसंछन्ना मन्दगाः कलुषाश्च याः ||

भा.प्र.पू.खं ६/३३३४

River water is drying enhances Vata, light to digest, appetizer, doesn't obstruct channels, clearing, pungent in taste and pacify Kapha and Pitta.Water from River, which flows fast with clear water is light to dig from sluggishly flowing rivers covered with algae, and filled with dirt digest.

Qualities of *Audbhida Jala :*

औभ्दिदं वारि पित्तघ्नमविदाह्यतिशीतलम् | प्रीणनं मधुरं बल्यमीषव्दातकरं लघु ||

भा.प्र.पू.खं ६/३९

Water from springs pacifies *Pitta*, non-irritant, very much cooling, satisfying, sweet in taste, strengthening, aggravates *Vata* slightly and is light to digest

Qualities of *Narzar Jala* :

नैर्झरं रूचिकृन्नीरं कफघ्नं दीपनं लघु | मधुरं कटुपाकं च वातलं स्यादपित्तलम् ||

भा.प्र.पू.खं ६/४१

Water from streams is palatable, pacifies *Kapha*, appetizer, light to digest, sweet in taste, pungent in post digestive effect, induces *Vata* but does not induce *Pitta*

Qualities of *Saras Jala* :

सारसं सलिलं बल्यं तृष्णाघ्नं मधुरं लघु | रोचनं तुवरं रूक्षं बध्दमूत्रमलं स्मृतम् ||

भा.प्र.पू.खं ६/४३

Water from lakes is strengthening, pacifies thirst, sweat and astringent in taste, light in digest, palatable, drying, constipation and reduces the quantity of urine.

Qualities of *Tadag Jala* :

ताडागमुदकं स्वादु कषायं कटुपाकि च | वातलं वध्दविण्मूत्रमसृक्पित्तकफापहम् ||

भा.प्र.पू.खं ६/४५

TadagaJala is palatable, astringent in taste, pungent in post digestive effect, induces *Vata*, constipative, reduces the quantity of urine and cures the aggravation of *Rakta*, *Pitta* and *Kapha*.

Qualities of *Vapya Jala* :

वाप्यं वारि यदि क्षारं पित्तकृत्कफावातहृत् | तदेव मिष्टं कफकृव्दातपित्तहरं भवेत् ||

भा.प्र.पू.खं ६/४७

Water from a well if alkaline, induces *Pitta* and pacifies *Kapha* & *Vata* and if sweet, induces *Kapha* and pacifies *Vata* & *Pitta*.

Qualities of *Kaupa Jala* :

कौपं पयो यदि स्वादु त्रिदोषघ्नं हितं लघु | तत्क्षारं कफवातघ्नं दीपनं पित्तकृत्परम् ||

भा.प्र.पू.खं ६/४९

Water from a well, if sweet pacifies *Tridosha,* ideal to drink and light to digest if alkaline pacifies *Kapha* and *Vata,* induces *Pitta* and acts as appetizer.

Qualities of *Chaundya Jala* :

चौण्डय वह्निकरं नीरं रूक्षं कफहरं लघु | मधुरं पित्तनुद्वच्यं पाचनं विशदं स्मृतम् ||

भा.प्र.पू.खं ६/५२

The water from a pit is appetizer, drying, pacifies *Kapha*, light to digest, sweet in taste, pacifies *Pitta,* palatable, digestant and clearing**.**

Qualities of *Palval Jala* :

पाल्वलं वार्यभिष्यन्दि गुरू स्वादु त्रिदोषकृत् || भा.प्र.पू.खं ६/५४

Water from a small pond blocks the channels, heavy to digest, palatable and induces *Tridoshas*.

Qualities of *Vaikira Jala* :

विकिरं शीतलं स्वच्छं निर्दोषं लघु च स्मृतम् | तुवरं स्वादु पित्तघ्नं क्षारं तत्पित्तलं मनाक् ||

भा.प्र.पू.खं ६/५६

VikiraJala is cooling, clear, doesn't induce *doshas*, and light to diget. If astringent and sweet it pacifies *Pitta* and if alkaline induces *Pitta*.

Qualities of *Kedar Jala* :

कैदारं वार्यभिष्यन्दि मधुरं गुरू दोषकृत् || भा.प्र.पू.खं ६/५७

Water from a *Kedar* blocks the channels, sweet in taste, heavy to digest and aggravates *doshas*.

Qualities of *Vrusti Jala :*

वार्षिक तदहर्वृष्टं भूमिस्थमहितं जलम् | त्रिरात्रमुषितं तत्तु प्रसत्रममृतोपमम् ||

भा.प्र.पू.खं ६/५८

Rain water collected from the ground on the same day causes diseas after three days it is clear and like nectar.

X) PROPERTIES AND CHARACTERISTICS OF GOOD POTABLE WATER

In olden days *Gangambu i.e.* rain water used to be pure and so good for health .The characteristic and properties of good potable water change according to seasons. Water properties are not permanent and constant. They change from place to place and season to season.

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *SUSHRUTA SAMHITA*-

निर्गन्धमव्यक्तरसं तृष्णाघ्नं शुचि शीतलम् |अच्छं लघु च हृद्यं च तोयं गुणवदुच्यते || सु.सू.४५/ २0

Water which has no smell, no prominent taste, quenches thirst, clean cold (cool), light (easy fir digestion) and pleasing to the mind to be best in qualities (suitable for drinking).

तत्र गाङ्गमाश्वयुजे मासि प्रायशो वर्षति | सु.सू.४५/ ७

The rain water falling in the month of *Ashwina* (September - October) is stated to be free from the dust, position, etc. Even if there is some contamination with dust etc. it does not so pollute water by virtue of the neutralizing factors in that season.

1) – B) REFERENCES FROM *CHARAKA* SAMHITA –

ईषत्कषायमधुरं सुसूक्ष्मं विशदं लघु |अरूक्षमनभिष्यन्दि सर्व पानीयमुत्तमम् || च.सू.२७/२0२

Best water is slightly astringent & sweet in taste, exceedingly thin, non slimy, light, soften, and non blocking of channels or non- greasy.

शीतं शुचि शिवं मृष्टं विमलं लघु षडगुणम् |प्रकृत्या दिव्यमुदकं भ्रष्टं पात्रमपेक्षते|| च.सू.२७/१९८

The rain water has by nature these six qualities - cold, pure, wholesome, palatable, clean and light.

1) – C) REFERENCES FROM *ASHTANG SANGRAHA* –

येनाभिवृष्टममलं शाल्यन्नं राजतस्थितम् |

अक्लिन्नमविवर्णं वा तत्तोयं गाग्ङमन्यथा || अ.सं.सू.६ / ५

Vagbhatta says that only rain water which neither makes the cooked Sail rice kept in a clean silver plate too moist (slimy)nor change its color is to be considered good for drinking.

2) REFERENCES FROM *LAGHUTRAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASH-*

अगन्धमव्यक्तरसं सुशीतं तर्षनाशनम् |

स्वच्छं लघु च ह्यद्यञ्ज तोयं गुणवदुच्यते || भा.प्र.पू.खं ६/७७

Water ideal for consumption should have no smell, no taste and cool, capable of pacifying thirst, clear, light to digest and cordial.

XI) PROPERTIES OF *DUSTA JALA* (Contaminated Water) & CAUSES OF WATER POLLUTION

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *SUSHRUTA SAMHITA-*

कीटमूत्रपुरीषाण्डशवकोथप्रदूषितम् तृणपर्णोत्करयुतं कलषं विषसंयुतम् || सु.सू.४५/ ९

योऽवगाहेत वर्षासु पिबेद्वाऽपि नवं जलम् स बाह्याभ्यन्तरान् रोगान् प्राप्नुयात् क्षिप्रमेव तु || सु.सू.४५/ १०

He who bathes by immersing in rain water, which has been contaminated with presence of insects (worms),or urine ,ova, dead bodies of animals ,which is purified, having great accumulation of grasses and leaves ,which is dirty or containing ,poisonous substance ,or who drinks fresh rain water during *Varsha Rutu* rainy season will get affected by both external and internal disease quickly.

तत्र यत् पङ्कशैवालहठतृणपदमपत्रप्रभृतिभिरवच्छन्नं रविशशिकिरणानिलैर्नाभिजुष्टं

गन्धवर्णरसोपसृष्टं तत्यापन्नमिति विद्यात् |

तस्य स्पर्शरूपरससगन्धवीर्यविपाकदोषाः षट् संभवन्ति |

तत्र खरता पैच्छिल्यमौष्ण्यं दन्तग्राहिता च स्पर्शदोष ः

पङ्कसिकताशैवालबहुवर्णता रूपदोष ः;व्यक्तरसता रसदोष ः; अनिष्टगन्धता गन्धदोषः;

यदुपयुक्तं तृष्णागौरवशूलकफप्रसेकानापादयति स वीर्यदोष ः;

यदुपयुक्तं चिराद्विपच्यते विष्टम्भयति वा स विपाकदोष इति | त एते आन्तरिक्षे न सन्ति ||

सु.सू.४५/ ११

Water which is covered over with slush, algae, weed grass, leaves of lotus etc., which is not exposed to rays of sun, moon and air, which is having odour, colour and taste very prominently, should be understood as polluted .Its blemishes will be of six kinds such as of touch, sight ,taste ,odour ,potency and taste after digestion; roughness (hardness) sliminess, warmth, producing tingling of the teeth are blemishes of touch ; presence of slush ,sand ,algae and many colours are blemish of sight ; prominence of taste is the blemish of taste; unpleasant odour is blemish of smell ; producing thirst ,feeling of heaviness, abdominal pain, more elimination of *Kapha* from the mouth etc. are blemishes of potency ; getting digested after a long time or causing constipation are the blemishes of taste after digestion .These blemishes are not present in atmospheric water (pure rain water).

व्यापन्नं वर्जयेन्नित्यं तोयं यच्च्याप्यनार्तवम् |
दोषसंजननं ह्येतन्नाददीताहितं तु तत् ||
व्यापन्नमुदकं यस्तु पिबतीहाप्रसादितम् |
श्वयथुं पाण्डुरोगं च त्वग्दोषमविपाकताम् ||
श्वासकासप्रतिश्यायशूलगुल्मोदराणि च |
अन्यान्वा विषमान्रोगन् प्रापुयादचिरेण सः ||

सु.सू.४५/ १४१५१६

Polluted water and rain water of unusual seasons should not be consumed every day both these produce aggravation of the *doshas* and are unsuitable to health he who drinks polluted water without purifying it, gets affected quickly by dreaded disease such as dropsy, anemia, skin diseases, improper digestion, dyspnoea, cough, nasal catarrh, abdominal pain, tumor of the abdomen, abdominal enlargement or any others.

1) – B) REFERENCES FROM *CHARAKA SAMHITA*–

वसुधाकीटसर्पाखुमलसंदूषितोदकाः |
क्रिमिलं क्लिन्नं पर्णशैवालकर्दमैं | विवर्ण विरसं सान्द्रं दुर्गन्धं न हितं जलम् || च.सू. २७/२१५

River water can be polluted with soil and faeces, insects, snakes and rats.

Slimly, having insects, unpurified, full of leaves, moss and mud, having abnormal colour and taste, viscous and foul smelling water is not wholesome.

1) – C) REFERENCES FROM *ASHTANG SANGRAH* –

कीटाहिमूत्रविट्कोथतृणजालोत्करविलम् | पङ्पङ्जशैवालहठपर्णादिसंस्तृतम् ||
सूर्येन्दुपवनादुष्टं जुष्टं च क्षुद्रजन्तुभिः | अभिवृष्टं विवर्णं च कलुषं स्थूलफेनिलम् ||
विरसं गन्धवत्तप्तं दन्तग्राह्यतिशैत्यतः | अनार्तवं च यद्दिव्यमार्तवं प्रथमं च यत् ||
लूतादितन्तुविण्मूत्रविषसंश्लेषदूषितम् | तत् कुर्यात् स्नानपानाभ्यां तृष्णाध्मानोदरज्वरान् ||
कासाग्निसादाभिष्यन्दकण्डूगण्डादिकानतः | तद्वर्जयेदभावे वा तोयस्यान्यस्य शस्यते ||

अ.सं.सू.६/२0ते २४

Water which has been contaminated with the urine, excreta and decomposed dead body of insects and snakes, which is having a net-work of weeds (grass)and rubbish, thick with presence of silt, plants growing in silt, algae, rootless plants, leaves covering the entire surface, sunlight and air not reaching the water at all; water full of insects, worms etc; water which is fresh but not fallen from the sky; water which is discolored, dirty, with big bubbles coming out of it ;of bad taste and foul smell, that which cause chills in the teeth being very cold, rain water which is unseasonal ,fresh rain water even proper season ,water that is polluted with urine ,excreta and poisonous matter from spiders and other insects- all these kinds of water are unfit for bathing or drinking, which is *dusta jala.* It will produce, if used, thirst distention, and enlargement of the abdomen, fever, cough, weak digestive capacity, ophthalamia ,itching and boils on the skin, hence such contaminated water should be rejected. If their use is unavoidable due to nonavailability of good water, they should be purified in the following ways and then made use of it.

2) REFERENCES FROM *LAGHUTRAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASH-*

पिच्छिलं कृमिलं क्लिन्नं पर्णशैवालकर्दमैः|विवर्णं विरसं सान्द्रं दुर्गन्धं न हितं जलम् ||
कलुषं छन्नमम्भोजपर्णनीलीतृणादिभिः | दुःस्पर्शनमसंस्पृष्टं सौरचान्द्रमरीचिभिः ||
अनार्त्तवं वार्षिकं तु प्रथमं तच्च भूमिगम् | व्यापन्नं परिहर्त्तव्यं सर्वदोषप्रकोपणम् ||
तत्कुर्यात्स्त्रानपानाभ्यां तृष्णाऽऽध्मानचिरज्वरान् | कासाग्निमान्द्याभिष्यन्दकण्डूगण्डादिकं तथा ||

भा.प्र.पू.ख्रं ६/७८ते ८१

REFERENCES OF *JALA ANIVARYATA* (IMPORTANCE OF WATER)

Jala is the life of all the animals. And the entire world is full of it. So absolute avoidance of *jala* is impossible *Haritmani* says *Trishna* is very dangerous as it destroys the *Prana*, so who is suffering from *Trishna* we have to give the *jala. Trishna* leads to *moha* and leads to *pranhani.* So in any condition we should never restrain from *jala*.

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *ASHTANG SANGRAH* –

पानीयं प्राणिनां प्राणा विश्वमेव च तन्मयम्

अतोऽत्यन्तनिषेधेन न कचिद्वारि वार्यते || अ.सं.सू.६ / २९

आस्यशोषाङ्सादाद्या मृत्युर्वा तदलाभतः

न हि तोयाद्विना वृत्तिः स्वस्थस्य व्याधितस्य वा || अ.सं.सू.६ / ३0

Water is the sustainer of life of all living beings, the entire world is full of it and so absolute avoidance of water is very difficult or impossible. Dryness of mouth, weakness of body etc; or even death might result if it is not available. Without water there is no activity in both healthy and sick persons.

REFERENCES OF *JALA SHODHANA* (PURIFICATION OF WATER)

1) REFERENCES FROM *BRUHATTRAYEE*

1) – A) REFERENCES FROM *CHARAKA* SAMHITA–

Charaka has described only properties of *Jala* in detailed but not mentioned ***Jala Shodhana*** i.e. purification of water.

1) – B) REFERENCES FROM *SUSHRUTA* SAMHITA–

"व्यापन्नस्य चाग्निक्वथनं सूर्यातपप्रतापनं तप्तायः पिण्डसिकतालोष्ट्राणां

वा निर्वापणं प्रसादनं च कर्तव्यं नागचम्पकोत्पलपाटलापुष्पप्रभृतिभिश्चाधिवासनमिति || सु.सू.४५/ १२

Boiling over fire, heating by exposing to sunrays, immersing heated iron balls, sand or stone into water are the method to purify contaminated water; putting flowers such as *Naga, Campaka, Utpala, Patala* etc; into water and allowing these for some time to stay in it (removes bad smell and imparts good smell).

In next reference ***Sushruta*** mentioned methods of storage of water -

सौवर्णे राजते ताम्रे कांस्ये मणिमयेऽपि वा |

पुष्पावतंसं भौमे वा सुगन्धि सलिलं पिवेत् || सु.सू.४५/ १३

Water kept stored in vessels made of gold ,silver ,copper ,bronze, precious stones or in earthen pots and made fragrant by putting flowers into it should be used for drinking .

After this he stated methods of clearing the turbidity of polluted water -

तत्र सप्त कलषुस्य प्रसादनानि भवन्ति |

तद्यथा कतकगोमेदकविसग्रन्थिशैवालमूलवस्त्राणि मुक्तामणिश्चेति || सु.सू.४५/ १७

Methods of clearing the turbidity of polluted water are seven such as by the use of *Kataka* (adding the paste of *Kataka*,(adding the paste of the *Kataka* nut to water) , *Gomedaka* (gem, dolomite) *Bis Granthi* (rhizome of lotus) *Shaivala Mula* (root of algae) these are immersed in water ;*Vastra* (cloth, filtering through it) *Mukta* (pearl) and *Mani* (crystals of rocks)or gems (by immersing in water).

Also *Sushruta* mentioned methods of the water cooling, which are seven such as –

सप्त शीतीकरणानि भवन्ति तद्यथा प्रवातस्थापनम् उदकप्रक्षेपणं

यष्टिकाभ्रामणं व्यजनं वस्त्रोद्धरणं वालुकाप्रक्षेपणं शिक्यावलम्बनं चेति || सु.सू.४५/ १९

Methods of keeping the water ,cool seven such as exposing to breeze keeping post of cold water one over the other , wrapping the post with cloth and sprinkling water frequently ,stirring with sticks ,fanning ,lifting through cloth (dipping clean cloth in water and lifting ,repeating this act frequently) keeping the water pot hidden in a sand bad and keeping the pot in a hanger (tied in open space and made to move like a pendulum).

1) – C) REFERENCES FROM *ASHTANG SANGRAH* –

घनवस्त्रपरिस्त्रावैः क्षुद्रजन्त्वभिरक्षणम् व्यापन्नस्यास्य तपनमग्न्यर्कायसपिण्डकैः
पर्णीमूलबिसग्रन्थिमुक्ताकतकशैवलैः वस्त्रगोमेदकाभ्यां वा कारयेत्तत्प्रसादनम्
पाटलाकरवीरादिकुसुमैर्गन्धनाशनम् || अ.सं.सू.६ / २५-२६

Polluted water should be filtered through thick cloth to remove insects and worms ,heated by fire, exposure to sunlight or by immersing red – hot iron balls into it ; it should be made clear by putting into it *Parnimula* (a kind of grass which has the property of diluting the water), knots (tubers) of lotus plant ,pearls, seeds of *kataka*, algae, thick cloth or *gomedaka* (dolomite stone) its bad smell being removed by putting into it the flowers of *patala, karavira* and such other sweet smelling ones.

2) REFERENCES FROM *LAGHUTRAYEE*

2) – A) REFERENCES FROM *BHAVAPRAKASH-*

निन्दितं चापि पानीयं क्वथितं सूर्यतापितम् | सुवर्ण रजतं लौहं पाषाणं सिकतामपि||
भृशं सन्ताप्य निर्वाच्य सप्तधा साधितं तथा | कर्पूरजातिपुन्नागपायलादिसुवासितम् ||
शुचिसान्द्रपटस्त्रावि क्षुद्रजन्तुविवर्जितम् | स्वच्छं कनकमुक्ताऽऽद्यैः शुध्दं स्याद्दोषवर्जितम् ||
पर्णीमूलबिसग्रन्थिमुक्ताकनकशैवलेः | गोमेदेन च वस्त्रेण कुर्य्याद् अंबुप्रसादनम् ||

भा.प्र.पू.खं ६/८२ ते ८५

Contaminated water can be made fit for use by boiling or exposing it to sunrays. Gold, silver, iron, stone or sand may be heated and dripped in water for seven times and fragranced with camphor and flowers of *Jati, Punnaga, Patala* etc. and filtered through a thick cloth to remove small insects to use the water. Gold, pearls make the water clear. Water can also be made clear with the help of *parnimula*, knots of lotus plant, pearls, gold, algae, cat's eye and cloth.

B) DESCRIPTION OF *JALA* (WATER) MODERN ASPECT

REFERENCES FROM PARK'S TEXTBOOK OF PREVENTIVE & SOCIAL MEDICIN –

Much of the ill health which affects humanity, especially in the developing countries can be traced to lack of safe and wholesome water supply. Water that easily accessible, adequate in quantity, free from contamination, safe and readily available throughout the year. There can be no state of positive health and well being without safe water. Water is not only a vital environmental factor to all forms of life, but it has also a great role to play in socio economics development of human population. Each country should develop its own water resources agency which would collect all pertinent data on water resource explosions and hydrogeology in 1980,the United Nation General Assembly launched the international Drinking Water supply and sanitation Decade,1981-1990 the aim being to provide all people with adequate supplies of safe water and sanitation by 1990 In 1981,the 34th World health Assembly in a resolution emphasized that safe drinking water is basic element of "Primary Health Care" Which is the key to the attainment of "health for all by the year 2000AD" Water is also integrated with other PHC components because it is an essential part of health education food and nutrition and also MCH.

WATER REQUIREMENT

The basic physiological requirements for drinking water have been estimated at about 2 lits /head/day. This is just for survival. A daily supply of 150-200 lits /capita is considered an adequate supply to meet the needs for all domestic purposes. In India 40 lits of water/capital/day is the set target to be achieved by the end of the 8th Five Year plan.

HOUSEHOLD NEEDS

A rough estimate of indoor usage can be made by using either 75gallons per day per person (GDP) for a house with older appliances and fixtures (or 55 GDP for a house with newer water saving appliances and fixtures) and multiplying the GDP by the number of people in the household. You can reduce your water needs. However, do not reduce your need calculations based on water conservation unless you actually practice water conservation techniques.

For a family of four living in a flat in urban area and with water-saving appliances and fixtures and not practicing water conservation techniques requires water as follows -

4 people x 55 gallons per day per person = 220 gallons of water per day used 220 gallons of water per day x 365 days per year = 80,300 gallons of water per year is used.

WATER REQUIREMENT IN CITIES IS ESTIMATED AS FOLLOWS

Fixture	**Use**	**Flow Rate**	**Total**
Toilet	3 flushes per person per day	1.6 gallons per flush *	19.2
Shower	10minutes per person per day(5 min. Max. Suggested)	2.75 gallons per minute *(restricted flow head)	110
Bath	One baths per person per day	50 gallons per bath average	200
Faucets	One bathroom, one WC and two kitchen sinks	10 gallons per day	40
Washing cloths and utensils	Two loads per day	50 gallons per load (average)	100
			469.2

Water needs for villagers is much less. Circumstances force them to use minimal water. It is roughly estimated that a villager uses about 30 L of water for all his/her needs. Drinking water needs in villages is less than 2 L a day per person. Many villagers use water from the irrigation canals, rivulets and brooks, wells etc. thus reducing the load on water stored in the house by the women family members of the house hold.

USES OF WATER

The uses of water in a community are many and the requirement in quantity and quality are varied.

The uses of water include

1) Domestic Use: On domestic front, water is required for drinking, cooking, washing and bathing, flushing of toilets, gardening etc.
2) Public Purposes: Cleaning streets, recreational purpose like swimming pools, public fountains and ornamental ponds, fire protection and public parks.
3) Industrial purposes: For processing and cooling.
4) Agricultural purposes Irrigation
5) Power Production: From hydropower and steam power.
6) Carrying away waste from all manner of establishments and institution.

As for the treatment purpose in naturopathy water is used for taking different types of baths. eg, Immersion bath, Sona bath etc.

Water is therefore an essential factor in the economic social and cultural development of a community. It can eliminate disease promote rural development and improve quality of life.

Function of water in the body

- Necessary for all chemical reaction in the body. Just as water helps as seed grow into a tree, it also helps our body grow from birth to adulthood.
- It regular the body temperature.
- It removes poisons or toxins from the body through urine, sweat and breathing.

SOURCES OF WATER SUPPLY & THEIR PROPERTIES

Earth is the "watery Plant" Viewed from space it is predominantly blue as74% of its surface is covered by water. There are326 million cubic miles of water on earth Oceans contain 97% of the earths water while the reaming 3% is classified as fishwater.77% of this surface freshwater is stirred as ice and22% as ground water and soil moisture. The remaining freshwater, making up less than 1% of the world total, is contained in lakes, rivers and wet-land. Water may be abstracted for use from any one of a number of points in its movement through the hydrological cycle.

Water source must conform to two Criteria.

a) The quantity must be sufficient to meet present and future requirements

b) The quality of water must be acceptable.

THERE ARE THREE MAIN SOURCE OF WATER

1) Rain -	
2) Surface Water -	Impounding Reservoirs
	Rivers and Streams
	Tanks, Ponds and Lakes
3) Ground Water -	Shallow wells
	Deep wells
	Springs
4) Other – (Present sources)	Tap water
	Bottled water

1) RAIN

Rain is the prime Source of all water.

Characteristics

Rain Water is the purest water in nature. Physically it is clear, bright, and sparking. Chemically it is very soft water containing only trace of dissolved solids (0.0005%) Bacteriologically, rain water from clean districts is free from pathogenic agents.

Impurities

Rain water tends to become impure as it passes through the atmosphere such as dust, soot and micro – organisms and gases such as carbon dioxide, nitrogen, oxygen and ammonia.

2) SURFACE WATER

Surface water originate from rain water .It is the main source of water supply in many areas. Examples of surface water include rivers, tanks, wadis (water source which are dry, expect in rainy season) man made reservoirs and sea water.

A) Impounding Reservoirs

These are artificial lakes constructed usually of earthwork or masonry in which large quantities of surface water is stored.

One disadvantage of storing water for long periods in reservoirs is the growth of algae and other microscope organisms, which impart bad tastes and odors to water.

Characteristics

Impounding reservoirs usually furnish a fairly good quality of water. The water is usually clear, palatable and ranks next to rain water in purity. If the surrounding hills are covered with peat, the water may acquire a brownish coloration. The water is usually soft and considered to be free of pathogenic organisms.

Impurities

The upland surface water derives its impurities from the catchment area, the source being human habitation and animal keeping or grazing.

B) Rivers

Many rivers furnish a dependable supply of water.

Characteristics

River water is turbid during rainy season; it may be clear in other season. Clarity of water is no guarantee that the river water is safe for drinking. River water contains dissolved and suspended impurities of all kinds. The bacterial count, including the human intestinal organisms may be very high.

Impurities

The impurities of river water are derived from surface washings, sewage and sludge water, industrial and trade waters and drainage from agricultural areas. The customs and habits of the people like bathing, animal washing and disposal of the dead, all ads to the pollution of water. Impurities in river water are natural and necessary to support the plants and animals. No fish, frog, insect, nor plant can live in distilled water.

Impurities enter the river during rain events, carrying runoff from the land or even particulate matter from the air. When water runs off the land it can erode soil and rocks, or pick up plant materials and carry these substances into rivers. Rivers have been classified according to the best way each can be used given its stream flow, adjacent land, and past and present desired uses of the water.

Self-Purification

Certain amount of self purification does occur in river water by natural forces of purification such as dilution, sedimentation, aeration, oxidation, sunlight, plant and animal life but these agencies are not sufficient to render the water potable.

Now a day's river water cannot be used for drinking purposes without treating it physically and chemically. River water is unprotected. It is subject to contamination by public and the domestic animals. It will also be heavily contaminated from the catchment areas and upstream areas.River water needs purification before it can be used for drinking purpose.

C) Tanks

Tanks are large excavation in which surface water is sorted. They are an important source of water supply of water supply in some Indian villages. Tanks are recipients of contamination of all sorts. They are full of silt and colloidal matter, especially immediately after the rains.

3) GROUND WATER

Rain water percolating into ground constitutes ground water. Water used by humans comes mainly from land .It is now realized that there is a limit to ground water in the world. We should withdraw only quantities of water that can be renewed.

Ground water is the cheapest and most practical means of providing water to small communities. Ground water is superior to surface water, because the ground itself provides an effective filtering medium.

Nationally, 53% of the population relies on ground water as a source of drinking water. In rural areas this figure is even higher. 81% of community water is dependent on ground water.

The advantages of ground water are

- It is likely to be free from pathogenic agents
- It usually require no treatment
- The supply is likely to be certain even during dry seasons.
- It is less subject to contamination than surface water.

The disadvantages of ground water are

- It is high in mineral content.
  e.g. Salts of calcium & magnesium which render the water hard.
- It requires pumping or some arrangements to lift the water.

The usual ground water source is wells and springs .Wells have been classified into shallow and deep wells. Dug and Tube wells.

A) WELLS

Types of wells - Water wells can be broadly classified into the following groups

i) Dug Wells
ii) Radial Collector Wells
iii) Naturally Developed Screened Wells
iv) Artificial Filter Pack Wells
v) Open Hole - Partially Cased Wells in Consolidated Formations
vi) Open Hole

i) Dug Wells –

Large diameter dug wells are built to obtain water from unconsolidated materials that normally occur in the first 50 feet beneath the surface. In this type of well that may range from 3 to 20 feet in diameter, the walls of hole are lined in such a way as to prevent cave in of the walls yet still to allow seepage of ground water into the well base to produce a reservoir of water.

ii) Radial Collector Wells –

This type of well usually is constructed of a concrete shaft or caisson from which horizontal intakes pipes project radically.

iii) Naturally Developed Screened Wells –

This type of well is built to obtain water at various depths from unconsolidated formations which can be stabilized naturally by development following the installation of the casing and screen.

iv) Artificial Filter Pack Wells –

This type of well is built to obtain water at various depths from unconsolidated formations that cannot be stabilized by the use of a casing / screen combination and natural development only , but in addition require the use of material (sand, gravel, rock) that is coarser than the formation material in the screened interval. This added material acts an additional screen to prevent the finer aquifer materials from entering the well.

v) Open Hole - Partially Cased Wells in Consolidated Formations-

This type of well is built to obtain water at various depths from consolidated formations (bedrock) either fractured or unfractured. It is not cased or screened in the producing zone, for no formation stabilization or filtering is needed, but it may be cased through the formation above the producing zone if it is unconsolidated or unstable to prevent borehole collapse or to exclude water of undesirable quality.

vi) Open Hole- Partially cased wells in Unstable – Consolidated Formations-

An additional well type is built to obtain water from unstable potentially caving formations. This type is usually screened through the producing zone and may, require the

addition of coarse filter material under some conditions. The well may not be cased through all the formations above the producing zone, except to exclude water of undesirable quality.

Traditionally wells are an important source of water supply. Even today, they are an important source of water supply in many communities. One advantage with well water is that it does not contain chlorine and chloramine. On the other hand, well water is frequently harder than water available through local utilities. In addition, the only way to know its composition is to run tests.

Technically, wells are of two kinds-shallow and deep –

DIFFRENCE BETWEEN A SHALLOW WELL AND DEEP WELL

	Shallow Well	**Deep Well**
Definition	Taps the water from above the first impervious layer	Taps the water from below the first impervious layer
Chemical Quality	Moderately hard	Much hard
Bacteriological quality	Often grossly contaminated	Taps purer water
Yield	Usually goes dry in Summer	Provides source of constant supply

B) TUBE WELLS

Tube wells are successful as a source of drinking water in many parts of India. They yield water which is bacteriologically safe & are also cheap in comparison to other sources of supply. Shallow tube wells or “driven wells” have become the largest individual source of water supply to the rural community. The tube well consists of a pipe sunk into the water bearing stratum & fitted with a strainer at the bottom, and a hand pump at the top. A water tight concretes platform with a drain all round should be kept free pollution with liquid and solid wastes. The life of tube well is not the same everywhere. It varies from place to place depending upon the type of strainer quality of underground water and the nature of soil. An average well may last for a period of 5 to 10 years; in some cases tube wells have given satisfactory service even after 30 years. When the tube well is derelict, it is withdrawn and then re - sunk with a new strainer using as much of the withdrawn pipes as can be recovered.

3) OTHER SOURCES OF WATER IN PRESENT ERA

A) Municipal Tap Water

Most people use tap water in their tanks; it is cheap and easy to use. Unfortunately, local water contains chemicals in the water to make it safe to drink e.g., chlorine or chloramines to kill bacteria.

Chlorine:

Tap water at any point contains a minimal chlorine concentration of 0.2ppm, and stringently limits the concentration of bacteria which may require more than 0.2 ppm chlorine.

B) Bottled Water, Mineral Water, Pouched Drinking Water

This type is launched by many companies. It is packed water either in bottles or plastics pouches of 600 ml to 5 liters or more. These are triple filtered water for sale. They are costly but useful while travelling or in remote places. Being sterile and reconstituted by addition of electrolytes and minerals and salts, it does not upset stomach or does not cause any water born diseases. Especially it is useful for children and sick persons who are travelling.

There are three kinds of bottled water – **Distilled, Purified and Spring.**

Distillation evaporates the water and then re-condenses it, thereby theoretically leaving all impurities behind (although some VOCs can pass right through this process with the water).

Purified water is usually prepared by reverse osmosis, de-ionization or a combination of both processes.

Spring water is usually acquired from a mountain spring or an artesian well, but it may be more than processes tap water. Spring water will generally have higher total dissolved solids than purified water.

HARDNESS OF WATER

Hardness may be defined at the soap destroying power of water. The consumer considers water hard if large amounts of soap are required to produce lather. The hardness in water is cause mainly by four dissolved compounds.

1) Calcium bicarbonate.
2) Magnesium bicarbonate
3) Calcium Sulphate
4) Magnesium Sulphate.

The presence of any one of these compounds produces hardness. There are others which are of less importance chlorides and nitrates of calcium and magnesium can also awareness hardness but they occur generally in small amounts.

Hardness is classified as carbonate and non bicarbonate. The carbonate hardness which was formerly designated as "temporary" hardness is due to presence of calcium and magnesium bicarbonates. The non carbonate hardness formerly designated as "permanent" hardness, is due to calcium and magnesium sulphates, chlorides and nitrates.

Hardness in water is expressed in terms of "milli - equivalents per liter (mEq/L)". One mEq/L of hardness producing ion is equal to 50 mg $CaCO_3$ (50 ppm) in one liter of water. The terms soft and hard water are used when the level of Hardness are as given under –

No	**Classification**	**Level Of Hardness (mEq/litre)**
1	Soft water	Less than 1(<50 mg/L)
2	Moderately Hard	1-3 (50 – 150 mg/L)
3	Hard Water	3-6 (150 – 300 mg/L)
4	Very Hard Water	Over 6 (>300 mg/L)

Drinking water should be moderately hard. Softening of water is recommended when the hardness exceeds 3mEq/L (150 mg per liter)

PROPERTIES AND CHARACTERISTICS OF GOOD POTABLE WATER

Water intended for human consumption should be both safe and wholesome. This has been defined as water that is –

a. Free from pathogenic agents

b. Free from harmful chemical substance

c. Pleasant to the taste i.e. free from color and odour

d. Usable for domestic purpose.

NEED FOR PURE WATER

The WHO has estimated that up to 80% of all sickness and diseases in the world is caused by polluted water.

Serious ill health can be caused by water supplies becoming contaminated from faeces being passed or washed into rivers, streams or pools or being allowed to seep into wells or bore holes.

The water borne diseases are transmitted through faeces and polluted water. Therefore, worldwide the most valuable test for routine quality control of water supply, as compare to other tests is the E.coli count in the water.

WATER POLLUTION

Pure uncontaminated water does not occur in nature. It contains impurities of various kind **natural and man made**. The natural impurities are not essentially dangerous.

Natural Impurities are –

Dissolved gases - eg nitrogen, carbon, dioxide, sulfide etc; which may be picked up during rainfall

Dissolved minerals.- eg; salt of calcium magnesium, sodium etc.which are natural constituents of water following its contact with soils

Suspended impurities - eg. clay salt and mud , microscopic organisms. These impurities are derived from the atmosphere, catchment area and the soil.

Man Made Impurities are –

A more serious aspect of water pollution is that caused by human activity urbanization and industrialization.

The source of pollution resulting from these are -

- Sewage, which contains decomposable organic matter and pathogenic agents.
- Industrial and trade wastes, which contain toxic agents ranging from metal salts to complex synthetic chemical.
- Agricultural pollutants, which comprise fertilizer and pesticides,
- Physical pollutant i.e. heat (thermal pollution) and radioactive substance.

The indicators of pollution include the amount of total suspended solids, biochemical oxygen demand (BOD) at 20^0 c, and concentration of chlorides, nitrogen & phosphorus and absence of dissolved oxygen.

Even if the source of water supply its treatment are of high standard water pollution may still occur a often happens due to corrosion of pipes lines, leaky joints and cross connection between water supply pipes and swage drainage pipes. Surveillance has to be exercised at every point in the distribution system to ensure supply of safe water to consumer.

WATER CONTAMINANTS

1) Biological Impurities: Bacteria, Viruses, and Parasites

Microorganisms originating from human and animal feces, or other sources, can cause waterborne diseases. Many of the minor illnesses and gastrointestinal disorders that go unreported can be traced to organisms found in water supplies.

Biological impurities have largely been eliminated in municipal water systems with chlorine treatment. However, such treated water can still become biologically contaminated. Residual chlorine throughout the system may not be adequate and therefore microorganisms can grow in stagnant water sitting in storage facilities or at the ends of pipes.

Water from private wells and small public systems is more vulnerable to biological contamination these system generally use untreated groundwater supplies, which could be polluted due to septic tank leakage or poor construction.

2) Organic Impurities - Tastes and Odours

If water has a disagreeable taste or odour, the likely cause is one or more organic substances, ranging from decaying vegetation to algae to organic chemicals (organic chemicals are compounds containing carbon.)

3) Inorganic Impurities - Dirt and Sediment, or Turbidity

Most water contains suspended particles of fine sand, clay, salt and precipitated salts. This cloudiness or muddiness is called turbidity. Turbidity is unsightly, and it can be a source of

food and lodging for bacteria. Turbidity can also interfere with effective disinfection and purification of water.

4) Toxic Metals or Heavy Metals

The presence of toxic metals in drinking water is one of the greatest threats to human health. The major culprits include lead, arsenic, cadmium, mercury, and silver. Maximum limits for each of these metals are established.

5) Toxic Organic Chemicals

The most pressing and widespread water contamination problem results from the organic chemicals (those containing carbon) created by industry. Synthetic organic chemicals have been detected in many water supplies throughout the country. They get into the groundwater from improper disposal of industrial waste (including discharge into waterways), poorly designed and sited industrial lagoons, wastewater discharge from sewage treatment plants, unlined landfills, and chemical spills.

The Scientific research linking various synthetic organic chemicals to specific adverse health effects is not conclusive and remains the subjects of considerable debate However given the ubiquity of these pollutants and their knows presence in water supplies and given some demonstrated toxicity association it would be reasonable to assume that chronic exposure to high levels of synthetic organic chemical in water could be harmful if they in your water you want to get them out. However only a fraction of these compounds have been tested for such effects. Well over three quarters of the substance identified by the EPA as priority pollutants are synthetic organic chemical in water could be harmful.

6) Pesticides and Herbicides

The increased use of pesticides and herbicides (means a thing that kills) in American agriculture since World War II has had a profound effect on water quality. Rain and irrigation carry these deadly chemicals into groundwater, as well as into surface waters. These are poisonous, plain and simple.

7) Total Dissolved Solids (TDS)

Total dissolved solids consist of rock and numerous other compounds from the earth. The significance of TDS in water is a point of controversy among water purveyors, but here are some facts sodium, barium, copper sulfates, and fluoride.

1. High TDS interferes with the taste of food and beverages
2. High TDS makes ice cubes cloudy, softer and faster melting
3. High TDS causes scaling on showers, tubs, sinks and inside pipes & water heaters.

   About the consequence of higher levels of TDS
4. High TDS results in undesirable taste which can be salty, bitter or metallic.
5. Certain mineral salts may cause health hazards .The most problematic are nitrates.
6. Volatile Organic Compounds (VOCs) - Volatile organic compounds are very lightweight

   organic chemicals that easily evaporate into the air.

   VOCs are the most prevalent chemicals found in drinking water and they comprise a large proportion of the substances regulated as priority pollutants by the EPA.

8) Chlorine

Chlorine is part of the solution and part of the problem. In 1974 it was discovered that VOCs known as trihalomethanes (THMs) are formed when the chlorine added to water to kill bacteria and viruses reacts with other organic substances in the water. Chlorinated water has been linked to cancer, high blood pressure, and anemia.

9) Asbestos

Asbestos exists in water as microscopic suspended fibers. Its primary source is asbestos cement pipe, which was commonly used after World War II for city water systems. It has been estimated that some 200000 miles of this pipe are currently in use delivering drinking water. Because pipes wear as water courses through them, asbestos shows up with increasing frequency in municipal water supplies. It has been linked to gastrointestinal cancer.

10) Radio-nuclides

The earth contains naturally occurring radioactive substances. Due to their geological characteristics, certain areas of the U.S. exhibit relatively high background levels of radioactivity. The three substances of concern to human health that show up in drinking water are uranium, radium, and radon (a gas). Various purification techniques can be effective at reducing the levels of radio-nuclides in water.

SUBSTANCES THAT GIVE BAD ODOUR TO POTABLE WATER

WATER QUQLITY POLLUTION

1) Non-persistent (Degradable)

- Domestic sewage
- Fertilizer
- Some industrial wastes.

These compounds can be broken by chemical reactions or by natural bacteria into simple non polluting substance such as carbon dioxide and nitrogen. The process can lead to low oxygen levels and eutrophication if the pollution load is high But damage is reversible.

2) Persistent (Degrade slowly)

- Some pesticides (e.g DDT dieldrin)
- Some leachate components from landfill sites (municipal industrial)
- Petroleum and Petroleum products
- PCBs, dioxins, poly aromatic hydrocarbons (PAHs)
- Radioactive materials such as strontium -90, cesium -137, radium - 226 and uranium.
- Metals such as lead mercury, cadmium.

This most rapidly growing type of pollution and includes substance that degrades very slowly or cannot be broken down at all; they may remain in the aquatic environment for year or longer periods of time. The damage they cause is either irreversible or reparable only over decades or centuries.

3) Other

- Warm water from cooling towers (thermal pollution)
- Floating Debris
- Garbage
- Foam

These are examples of physical pollution which interferes mainly with the usability and or aesthetic appeal of the water. In certain cases, thermal pollution can kill fish.

WATER RELATED DISEASES

Mans health may be affected by the ingestion of contaminated water either directly or through food and by the use of contaminated water for purpose of personal hygiene of recreation. The term water related disease includes the classical water borne disease. Developing countries carry a heavy burden of water related disease the heaviest being the diarrheal disease. Water related disease may be classified as follows –

1. Those caused by the presence of an infective agent

a. Viral – Viral Hepatitis, A Hepatitis E, Poliomyelitis, Rotavirus, Diarrhea in infants
b. Bacterial – Typhoid and paratyphoid fever, Bacillary Dysentery, Eschiocoli, Diarrhea, Cholera.
c. Protozoal – Amoebiasis, Giardiasis
d. Helminthic – Roundworm, Threadworm, Hydatide disease
e. Leptospiral – Weils disease

2. Those due to the presence of an aquatic host

a. Snail – Schistosominas
b. Cyclops – Guineaworm , Fish tape worm .

PURIFICATION WATER

Purification of water is of great importance in community medicine. It may be considered fewer than two heading -

A) Purification of water on large scale

B) Purification of water on small scale

A) PURIFICATION OF WATER ON LARGE SCALE

The purpose of water treatment is to produce water that is safe and method of treatment to be employed depends upon the nature of raw water and the desired standards of water quality.

For example ground water (eg. wells and springs) may need no treatment other than disinfection. Surface water (eg. River water) which tends to be turbid and polluted requires extensive treatment.

The compounds of a typical water purification system comprise one or more of the following measures.

1) Storage

2) Filtration

3) Disinfection

1) STORAGE

Water is drawn out from the source and impounding in natural or artificial reservoirs. Storage provides a reserve of water from which further pollution is excluded. As a result of storage a very considerable amount of purification takes places.

2) FILTRATION

Filtration is the second stage in the purification of water and quite an important stage because 98-99% of the bacteria are removed by filtration apart from other impurities.

3) DISINFECTION

In water works practice the term disinfection is synonymous with chlorination. Ozonation & Ultraviolet radiation are available the other agents for water disinfection but these methods are costly as compare to chlorination.

B) PURIFICATION OF WATER ON SMALL SCALE

1) Household Purification of water
2) Disinfection of wells

1) Household Purification of water

Three methods are generally available for purifying water on an individual or domestic scale .These methods can be used singly or in combination.

a) Boiling
b) Filtration
c) Chemical disinfection –
    1) Chlorination
        i) Bleaching powder
        ii) Chlorine solution
        iii) Highest hypochlorite
        iv) Chlorine tablets

    2) Iodination - Use of Iodine
    3) Use of Potassium permanganate

a) Boiling -

Boiling for 5-10 minutes kills all microbes. Water should be boiled, cooled and stored till consumption in one and same container to avoid risk of contamination. Water looses taste. Method needs fuel expenditure.

b) Filtration:

The word ‘filter’ usually refers to a mechanical filter, which strains the water, and / or a carbon filter system, which reduces certain impurities by chemically bonding them – especially chlorine, lead and many organic molecules. Purification refers to a slower process, such as reverse osmosis, which greatly reduces dissolved solids, hardness and certain other impurities as well as many organics. Many systems combine both processes. Make sure that the claims of any filter or purifier you consider have been verified by independent testing.

Domestic water filters which run on electricity are good. Their use makes the water extra pure & increases the safety. But they require maintenance and they are not within the reach of rural population. Many models are available. They use activated charcoal, iodine, silver compounds, ultra violet rays etc. for purifications. Many filters have multiple stages for purification of water. Some models use membranes and have reverse osmosis (RO) mechanism. All models are handy, small and useful. The water should be caused only for drinking and cooking purposes.

Filtration through ceramic filters as Pasteur Chamberland filter, Berkfeld filter and Katadyn filter. The filter candle made of porcelain in the Chamberland type and of Kieselgurh or infusorial earth in the Berkfeld filter. In katudyn filter candle is coated with silver catalyst, so that bacteria coming in contact with surface are killed by ‘Oligodynamic action’ of silver ions, which are liberated into water. Candles of the fine type usually remove bacteria found in drinking water but not filter passing viruses. Inside the filters, the filtration as well as storage and sedimentation of impurities take place. Filter candles should be washed, scraped, boiled and dried for reuse at least once a week.

c) Chemical disinfection –

1) Chlorination

Bleaching powder, chlorine tablets, high test hypochloride and like chemicals having ingredient chlorine which form hypochloric acid in water is available.

2) Iodination

During emergency 2 drops of medicinal iodine (2% ethanol solution of iodine) for 1 liter of water. High cost and thyroid activity are its major disadvantages. High cost & the fact that the element is physiologically active (thyroid activity) are its major disadvantages.

3) Use of Potassium permanganate

Once widely used it is no longer recommended for water disinfection. It has other drawbacks too , such as altering the colour, smell & taste of water.

Storage, Sedimentation and Filtration:

Storage for six to eight hours settles the impurities in it by gravitational force. Turbidity reduces, light penetration increases, oxidation is enhanced. The supernatant water can be further filtered through multilayered fine cloth. It should be chlorinated before consumption.

SPECIAL TREATMENTS OF WATER

Removal of hardness, Fluoridation of water & Defluoridation of water are the specific treatments of water needed for specific water in specific area.

1) **Removal of Hardness –** If hardness of water exceeds 3mEq/L (150 mg per liter) softening of water is recommended. The methods of removal of hardness are briefly stated as below –

   A) Methods for Temporary hardness -
   - i) Boiling
   - ii) Addition of lime
   - iii) Addition of sodium carbonate
   - iv) Permutit process

   B) Methods for permanent hardness –
   - i) Addition of sodium carbonate
   - ii) Base exchange process

2) Fluoridation of water –

Fluorine is one of the constituents naturally present in water supplies. In fact, the main source of fluorine is drinking water. Deficiency of fluorine in drinking water is associated with dental caries and excess with Dental & Skeletal Fluorosis. Leading workers in India regard Fluorine in concentration of 0.5 to 0.8 ppm in drinking water as optimum (a concentration of 1ppm is regarded as optimum in temperate climates because the consumption of water is low)

The term Fluoridation Hs been given to the process of supplementing the natural fluoride content of potable waters to the point of optimum concentration. The WHO in 1969 recommended fluoridation of community water supplies in areas where the total intake of fluorides by the population is below the optimal levels for protection against dental caries. Fluoridation is now an accepted public health procedure in many developed countries.

3) Defluoridation of water –

In some geographic areas water may contain a high level of Fluorides. In such communities water should be defluoridated by phosphate to reduce Fluorides to optimum levels.

WATER QUALITY CRITERIA AND STANDARDS

The quest for pure water dates back to antiquity. In modern times, it has led to the formulation of specific standards to provide a basic for judging the quality of water. These standards are exposer limits for bacteriological, viral, chemical and physical agents that have been adopted by governments or appropriate authorities and therefore have legal force .The purpose of standers is to minimize all the known health hazards, since it is obviously impossible to prevent all pollution.

The who has published in 1993 vol.1and in 1996 vol.2 of second edition of guidance for drinking water quality intended for use by countries or a basic for the development of standers, which of properly implemented, will ensure the safety of drinking water supplies. In order to define standards, it is necessary to consider these recommendations in the context of prevailing environmental, social, economic and cultural conditions. These guidelines are intended to supersede the guidelines for drinking water published in 1984.

The guidelines for drinking water quality recommended by WHO (1993 & 1996) related to following variables –

I Acceptability aspects
II Microbiological aspects
III Chemical aspects
IV Radiological aspects

I ACCEPTABILITY ASPECTS

A) Physical parameters - Turbidity, Colour, Temperature, Taste / Odour
B) Inorganic constituents – Hardness, Chlorides, Ammonia, pH, Hydrogen sulphide,Iron, Sodium, Sulphate, Total dissolved solids, Zinc, Manganese, Dissolved oxygen, Copper & Aluminium .

II MICROBIOLOGICAL ASPECTS

A) Bacteriological Indicator – Coliform organisms, Faecal streptococci, Cl. Perfringens,
B) Virological aspects –
C) Biological aspects- Protozoa, Helminths, Free- living organisms

III CHEMICAL ASPECTS

A) Inorganic constituents – Arsenic , Cadmium, Chromium, Cyanide, Fluoride, Lead, Mercury, Nickel, Nitrate, Nitrite, Selenium etc.
B) Organic constituent - Chlorinated alkanes, chlorinated ethenes, Aromatic hydrocarbons.

COLLECTION OF WATER SAMPLE FOR TESTING – STANDARD PROCEDURE

1) SAMPLES FOR PHYSICAL AND CHEMICAL EXAMINATION

Samples for Physical and Chemical examination should be collected in the clean glass stopper bottles made of neutral glass of capacity not less than two liters. Stopper glass bottles technically known as "Winchester Quart Bottles"are suitable. Before collecting the sample rinse the, bottle well three times with the water, fillings it each time about1/3 full. Then fill it with the water, tie the stopper tightly down, with a piece of cloth over it and seal the string.

2) SAMPLE FOR BACTERIOLOGICAL EXAMINATION

Samples for bacteriological examination should be collected in clean sterilized bottles made of natural glass, of capacity 200-250 ml and provided with a ground glass stopper having an overlapping rim. The stopper must be relaxed by an intervening strip of paper to prevent breakage of the bottle during sterilization or jamming of the stopper. The stopper and the neck of the bottle should be protected by a paper or parchment cover. If the water to be sampled contains, or is likely to contain chlorine, a small quantity of Sodium thiosulphate (0.1ml of 3.0% solution or a small crystal of salt) should be added to the bottle before sterilization .Sterile sampling bottles should be obtained from the laboratory which is to carry out the analysis. The sampling bottle should not be opened until the moment at which it is required for filling.

a) COLLECTION OF SAMPLE FROM A TAP

When the sample is to be taken from tap in regular use, the tap should be opened fully, and the water run to waste at least for 2 minutes in order to flush the interior of the nozzle & to discharge the stagnant water in the service pipe. In the case of sample to be collected from taps which are not in regular use, the tap should be sterilized by heating it either with a blow lamp or with an ignited piece of cotton soaked in methylated spirit, until it is unbearably hot to the touch. Then the tap should be cooled by allowing the water to run to waste before the sample is collected.

The bottle should be held near the base with one hand and the stopper & paper cover over it removed together and held in the finger. The sample bottle should be filled from a gentle stream

of water from the tap, avoiding splashing. The collection of sample from taps which are leaky, should be avoided because the water might run down the outside of the tap and enter the bottle causing contamination. If this cannot be avoided, special precaution should be taken to clean the outside of the tap and to flame it sufficiently to ensure sterility.

b) COLLECTION OF SAMPLE FROM RIVER, LAKES, RESERVIORS, WELLS ETC.

Samples from river should not be taken too near the bank or too far away from the point of draw off. For collecting samples directly from rivers, lakes, tanks, wells etc. a bottle with a string attached to the neck which is fully wrapped in a paper and sterilized should be used. Before taking the sample, the paper cover should be removed, taking care not to allow the sides of the bottle to come in contact with anything. Another long clean string should be tied to the end of the sterilized string, and the bottle lowered in to the water and allowed to fill up. The bottle should be then raised and the stopper with cover replaced.

TRANSPORT AND STORAGE OF SAMPLES

The Bacteriological examination of the sample should be commenced as soon as possible after collection. Where this is not feasible, the sample should be kept in ice until it is taken for analysis. All such iced samples should be taken for analysis within 48 hours after collection. Samples not preserved in this manner should not be accepted for bacteriological examination. Certain particular regarding the date& time of collection and dispatch, source of water , particulars of recent rain falls and finding of the sanitary survey should also be supplied with the sample.

LITERARY REVIEW OF *TAMRA*

A) LITERARY REVIEW OF *TAMRA* (COPPER) AYURVEDIC ASPECT

SYNONYMS OF *TAMRA* :

Anuvindum, Arvindam, Ambakam, Araktaka, Arkam,Brahma Vardhanam, Brahma Varchasam, Kamodam, Bhaskaram,Hemagarbham, Neelavatam, Kaniysam, Lohitayasam, Malechchham,Nagasyamardanam, Nepaleeyam, Raktam, Rakta, Dhatu, Rakta Lauham, Ravipriyam, Raktapriyam, Rajivam, Shulvam, Suryalauham,Suryasthanam, Tapnestam, Tamrakam, Trilochanam, Trymbakam,Udumbar, Ushnam, Varishthanam, Vantikam, Visanshanam1.

Tamra Dhatu comes under the group of *Shuddha Lauha* which is described by every classical text *of Rasashastra.*

VERNACULAR NAMES OF *TAMRA:*

Hindi	-	*Tamba*
Bengali	-	*Tama*
Marathi	-	*Tambe*
Gujarati	-	*Trambo*
Kannaa	-	*Tamra*
Tamil	-	*Tamram*
Areban	-	*Tuhas*
English	-	Copper
Latin	-	Cuproum

UTAPPATI OF *TAMRA:*

From ancient time business of *Tamra* (Copper) was in practice in India. Minerals of the copper (*Tamra*) are widely distributed in India as well as the various countries of the world. According to the ancient texts of the Rasashastra Nepal and its neighboring countries are described as places of better variety of copper. In ancient days it was produced by smelting in some of the districts of Bihar.In India Simha bhumi in Bihar, hajaribaga , Kumau, Bouda & Been

district in Barma , Rajasthan , Orrisa, Bangal , Bramhadesh , Madras , Mahisura, Mumbai, Rajaputana, Ratnagiri, Haidarabada etc. are the places where minerals of *Tamra* (Copper) were found in large amount.

REFERENCES FROM THE *VEDA:*

In *Rigveda*- The word '*Tamra*' is not found in Vedic literature but the words *Lohitayas* and *Krishnayas* are found in *Atharvaveda* and *Shatpatha Brahmana* for copper and iron respectively. The word *Tamra* is first found in *Samhita* of *Yajurveda, Atharvaveda, Brahmanas* and *Upanishadas.*Initially, the word *Tamra* and *Lohitayas* both are used but gradually *Tamra* becomes more popular.

REFERENCES FROM THE *PURANA:*

In *Varaha Purana-* There is good mythological story about genesis of *Tamra* in *Varaha Purana. Tamra* is said to have originated from the semen of Kartikeya, which fell on the earth .
According to Rasakamadhenu, *Sulva* had its origin from Surya (sun).

REFERENCES FROM *BRUHATTRAYEE:*

Acharya Charaka has mentioned *Tamra* as one of the six metals in different places of *Samhita, Tamra* is mentioned as drug for various diseases like *Hikka, Swasa, Kasa, Abhishyanda, Timira, Sidhma* and *Kilas.* It is also mentioned as a *Rasayana* and for the treatment of *Garavisha.*

Acharya Sushruta classified *Tamra* with other metals in *Sutrasthana* along with its pharmacological properties and actions. In *Dravadravya Vidhi* chapter under *Sutrasthan* he mentioned that water kept stored in vessels made of gold ,silver ,copper ,bronze, precious stones or in earthen pots and made fragrant by putting flowers into it should be used for drinking .It is indicated in several diseases like *Krimi, Pandu, Prameha. Tamra Churna* is indicated in *Upadansha, Abhishyanda.* It is indicated that *Shalaka* and *Basti Netra* should be made up of *Tamra.*
In *Ashtanga Sangraha* pots made up of *Tamra* are used to store medicines.

REFERENCES FROM *RASASHASTRIA GRANTHAS:*

In Rasahridaya Tantra author Govinda Bhagavata Pada, gives good description of metals with different varieties of Tamra.

In Rasendra Chudamani Somadeva described the processes of Shodhana, Marana and pharmacological actions.

Acharya Dhundhukanath described method of Shodhana, Marana and Amrutikarana.

In Rasachintamani Acharya Anantdeva Suri described the special method of preparation of *Shweta Bhasma* of *Tamra.*

AVAILABILITY OF *TAMRA*:

Mineral sources

- *Tuttha*
- *Swarna Makshika*

Animal sources

- Peacock's feather
- *Bhunag*

VARIETIES OF *TAMRA:*

Only two types of *Tamra* are described – *Nepalaka* and *Malechchha*.

Nepalaka Tamra is very smooth, ductile, heavy, free from defects and used for medicinal purposes.

Malechchha Tamra is white or red in colour and highly emetic but it is not used for medicinal purposes.

Copper having red colour, glossy, and softness is considered the best as it is claimed to be pure and free from impurities, while the blackish and hard copper is considered inferior. Because it may contain lead, iron etc. as impurities and hence not recommended.

The text other than 'Rasarnava' (Ra. Chu, R.P.S., and R.R.S.) describes its varieties on the basis of the mines or place from which it is obtained.

On the basis of *Tamra* obtained from the mines of Nepal is considered the best while that which is obtained from the mines of other places is considered inferior and not recommended for therapeutic uses.

LITERARY REVIEW OF COPPER (*TAMRA*) MODERN ASPECT

REFERENCES FROM MODERN CHEMISTRY – Periodic Table – Elements - Copper

Copper is a chemical element with the symbol Cu.
Copper comes from the Latin word **cuprum**, meaning "from the island of Cyprus."

HISTORY OF COPPER:

Copper is man's oldest metal, dating back more than 10,000 years. A copper pendant discovered in what is now northern Iraq has been dated to about 8,700 B.C. In 3000 B.C., coppers ores were found in the island of Cyprus. Romans named the metal as cyprium which was later known as cuprum and then copper in English. In India copper was used to sterilize drinking water 2600 and 2200 B.C. It is still used in many households for storing water. In Egypt copper compounds were recommended for headaches, burns, wounds, and Boils (1500 BC). The Egyptians used the ankh symbol to denote copper in their system of hieroglyphs. It also represented eternal life. Greeks used it for treatment of ulcers and healing wounds. In the 20^{th} century, a German physician observed copper mine workers to be free from Arthritis. Earlier water supply used to be through copper pipes and taps and its anti-microbial properties were observed.

Copper is one of the oldest metals known to civilization. Its uses and contributions continue to grow. Copper is a vital and positive contributor to humankind and has improved our quality of life for centuries. Copper is the only metal other than gold that has natural color. Other metals are either gray or white. Over 400 copper alloys are in use today. Brass is an alloy of copper and zinc. Bronze is an alloy of copper and tin, aluminum, silicon, and beryllium.

AVAILABILITY OF COPPER :

Minerals of the copper (*Tamra*) are widely distributed in the various countries of the world. According to the ancient texts of the Rasashastra Nepal and its neighboring countries are described as places of better variety of copper.
International distribution of copper is as follows:

South America parallel, North America, Southern part of Africa, Russia, South West part of Europe and South East part of Asia, Australia and in Afghanistan the ores of the copper and the mines are found. Copper in India is procured in considerable amount since long back, mainly

in Rajasthan, Bihar, Karnataka, Andhrapradesh and in U.P. Ores of the copper are present in Himalaya areas as Kulu, Garhwal, Nepal, Sikkim and Bhutan.

Nowadays, copper is procured mainly from the Khetri district of Rajasthan and on the basis of its huge presence in the district it is also named as "Copper". Copper has a characteristic reddish brown colour when its clean surface is seen by reflected light; but in transmitted light its thin layers are green in appearance.It can be obtained in octahedral crystals.

PHYSICAL PROPERTIES OF COPPER:

- Copper has a characteristic reddish brown colour
- It is highly malleable & ductile at ordinary temperature.
- It becomes brittle near melting point
- It is good conductor of heat & electricity
- Its conductivity is almost as much as that of silver, the best conductor among all the metals.

Copper is a reddish metal with a face-centered cubic crystalline structure. It reflects red and orange light and absorbs other frequencies in the visible spectrum, due to its band structure, so it as a nice reddish color. It is malleable, ductile, and an extremely good conductor of both heat and electricity. It is softer than zinc and can be polished to a bright finish. It is found in group Ib of the periodic table, together with silver and gold. Copper has low chemical reactivity. In moist air it slowly forms a greenish surface film called patina; this coating protects the metal from further attack.

CHEMICAL PROPERTIES OF COPPER:

1) Atomic number	- 29
2) Atomic weight (mass)	- 63.546 $g.mol^{-1}$
3) Melting point	- 1083^0C
4) Specific gravity (Density)	- 8.92 $g.cm^{-3}$ at 20^0C
5) Boiling point	- 2595^0C
6) Thermal conductivity	- 0.92 cal/sq cm / sec / ^0C
7) Specific heat	- 0.92 cal /g / ^0C
8) Co-efficient of thermal expansion	-16.6 X 10-6/0C at 20^0C
9) Latent heat of fusion	- 45.7 – 50.46 cal/g
10) Electric resistively	- 1.7241 microhms /cc at 20^0C
11) Isotopes	- 6

Copper melts at 1083^0C if heated in an atmosphere of carbon monoxide, in air the melting point is some 200C lower owing to formation of cuprous oxide which dissolve in the molten metal. It is fairly dense metal, its specific gravity being 8.92 at 20^0C and it is an excellent conductor of heat and electricity. Copper does not burn in air but is gradually converted in to cuprous (Cu_2O) and Cupric (CuO) oxides on its surface when heated to redness. Copper is placed after hydrogen in the electrochemical series and hence does not react with acids unless they are also oxidizing agents and form complex ions with copper. It is, however, also slowly attacked by some acids in presence of air, owing to the slow oxidizing action of the air.

Although unaffected by dry air at ordinary temperature, exposure to moist air causes the formation of a beautiful green coating or patina. This was for long said to be a basic copper carbonate, but Vernon and Whitly (1929) have shown its, is inland places as basic sulphate $CuSO_4$.3Cu(OH)2, while near sea this is accompanied by a basic chloride $CuCl_2$ 3Cu(OH)2.

Copper reacts readily with nitric acid, oxides of nitrogen being formed. With the dilute acid, nitric oxide (along with a little nitrogen peroxide) is formed, while with the concentrated acid nitrogen peroxide predominates:

$3Cu + 8HNO_3 = 3Cu(NO)_3 + 2NO + 4H_2O$

$Cu + 4HNO_3 = Cu(NO3) + 2NO_2 + 2H_2O$

It is curious to note, however, that copper is not attacked by nitric acid which has been completely free from nitrous acid. Copper is not attacked by dilute hydrochloric acid in absence of air or oxidizing agents, by the concentrated acid even hot, but in presence of air a solution of Cupric Chloride is readily formed.

$Cu + 4HCl + O_2 = 2CuCl_2 + 2H_2O$

Copper is only attacked by dilute sulphuric acid if air is present, and then only slowly, in case copper sulphate results.

$2Cu + 2H_2SO4 + O2 = 2CuSO_4 + 2H_2O$

Hot concentrated sulphuric acid readily reacts with copper, sulphur dioxide being evolved.

$Cu + 2H_2SO_4 = CuSO_4 + SO_2 + 2H_2O$

Fine powder of copper burns in chlorine gas and produces cupric chloride.

$Cu + Cl_2 + CuCl_2$

Being as more reactive it replaces the place of silver from silver nitrate solution.

$2AgNO_3 + Cu + = Cu\ (NO_3) + Ag$

Caustic alkali solutions are without action on copper. As it is so low in electrochemical series, copper is displaced from solution of its salts by many metals e.g. Zinc or iron.

$Zn + CuSO_4 = Cu + ZnSO_4$

$Fe + CuSO_4 = Cu + FeSO_4$

Near its melting point copper is brittle enough to be powdered. Upon heating and then slowly cooling the metal is brittle, but if cooled rapidly soft, malleable and ductile product is obtained. It colors the Bunsen flame green. Exposed to the atmosphere, polished surface tarnishes slightly.

Its combinations are numerous and important. Although at least four oxides are said to be known two of them are of particular importance, namely red cuprous oxides, Cu_2O and black Cupric Oxide CuO. The important copper salts are usually cupric compounds. With metals copper form numerous alloys which that with Zinc called brass and that with tin called bronze are most beautiful.

ALLOYS OF COPPER:

Copper readily forms alloys with other metals and many of these are of considerable importance technically.

Bronze is the name originally given to copper-tin alloys but now a day this name is used for almost all Copper alloys in which resistance to wear is an essential characteristic. Manganese Bronze is a high tensile bronze containing a little manganese. Bronze are tough and tenacious material. Ordinary bronze is used for making statue, coins, ornaments etc. Phosphor-bronze is one of the strongest non-ferrous metals and is used in bearings, valves etc., where strength and resistance to wear must be combined with resistance to corrosion.

Lead is frequently added to improve anti-friction and machining qualities. Manganese bronze is used for the propellers of ships and machinery generally. Aluminum bronze is a hard, light, yellowish, bronze alloy used for making the hulls of yatches etc. Silicon bronze is used for telegraph wires.

Brass is fairly soft alloy and can be readily turned on a lathe or otherwise worked. It is an alloy of copper and zinc. There are many different types of brass, bell metal is used in bell

founding, gun metal was formerly used for making canon and now finds other uses, particularly for engineering purpose such as for gears and bearings. Speculum metal for optical instruments and German silver for making resistance coils for emaciating silver. Delta metal is described for a very high tensile strength. Monel metal is copper-nickel alloy which also has a high tensile strength and in addition is very resistant to chemical action, so that it is extensively employed in chemical industry.

Tellurium copper alloy came into prominence during the war (1939–45) improves copper machining quality to a large extent.

Copper alloys are extensively used in coinage and gold silver used in jewelry are usually alloyed with copper to give them hardness and durability without detracting from their appearance. Gold and silver coins usually contain 8% – 10% of copper.

USES OF COPPER:

- For alloys
- In coins, household utensils and vessels of brewery.
- For electrical goods manufacturing and for the steam boilers.
- In electroplating and electrotyping.
- Preparation of compounds for insecticides.
- As nails, rivets and sheeting for wooden ships.

Most copper is used for electrical equipment (60%); construction, such as roofing and plumbing (20%); industrial machinery, such as heat exchangers (15%) and alloys (5%). The main long established copper alloys are bronze, brass (a copper-zinc alloy), copper-tin-zinc, which was strong enough to make guns and cannons, and was known as gun metal, copper and nickel, known as cupronickel, which was the preferred metal for low-denomination coins. Copper is ideal for electrical wiring because it is easily worked, can be drawn into fine wire and has a high electrical conductivity.

HEALTH BENEFITS OF COPPER:

- Copper is primary element to produce melanin (pigmentation of eyes, hair and skin) in our bodies.
- Copper is also an Antioxidant and anti-carcinogenic that prevents cell damage and slows aging.
- Copper also helps in healing wounds and relieving pains
- Copper helps in formation of new cells, iron absorption and sugar absorption
- Copper is widely known as brain stimulant. Copper possess anti-convulsions properties and prevent from seizures. It synthesizes phospholipids that are essential for myelin (nerve coating) formation.
- Copper has anti-inflammatory properties and helps in Arthritis and other inflammatory pains
- Copper is needed for general cardiovascular health
- Copper may prevent from premature aging and degenerative diseases, heart diseases, autoimmune diseases, Arthritis, cataracts, Alzheimer's disease, Diabetes
- It regulates thyroid glands
- It is essential for haemoglobin synthesis, bone strength and immunity building
- Copper helps in maintaining digestive health

FOODS THAT CONTAIN COPPER:

Copper is vital to the health of humans, animals and plants and an essential part of the human diet. Copper-rich foods include dried beans, almonds, broccoli, chocolate, garlic, soybeans, peas, whole wheat products, seafood, honey, green leafy vegetables etc.

RECOMMENDED DOSAGE:

Human body cannot synthesize copper and to carry out normal metabolic functions copper intake is essential. Average intake of 1.2 mg/day (trace amounts) is recommended for adults. In a copper jug, copper intake is only in trace amounts that can’t be toxic.

DEFICIENCY OF COPPER:

Deficiency of copper can cause anaemia, Osteoporosis, low WBCs, elevated cholesterol, low skin pigmentation, thyroid problems, nervous system disorders etc.

EXCESSIVE COPPER INTAKE MAY CAUSE:

- Toxicity due to over dosage
- Excessive intake can be harmful also leading to high blood pressure, psychiatric disorders etc. A person should stop taking copper supplements and seek medical help immediately if having symptoms of anaemia, nausea, vomiting or abdominal pain.
- Pregnant women or people already on some kind of copper supplementation should consult their physicians before trying the product. Excessive copper intake may cause Zinc deficiency

LITERARY REVIEW OF WATER AND COPPER

METAL WITH WATER –

They react with water to form oxides and hydroxides. Some metals reacts with cold water , some with hot water & some with stem.

Healing with metals is an ancient Ayurvedic therapy. Metals like gold, silver, copper, Iron etc. have been used to treat various health problems in Ayurveda. Many Ayurvedic medicines use gold, silver, copper& iron *bhasm* (ash) as one of their ingredients. Also it was and is a common practice in India to put a gold or silver foil in *murabbas*, *chyawanprash* and medicines even today. *Paan*, the Indian betel leaf mouth freshener and digestive, is covered in silver foil before being given to the customer. All this just shows the importance these metals have on our health and well being.

In ancient times, it was a practice to use gold, silver, copper, bronze or earthen utensils and cutlery to serve and eat food and to store & drink water from these metallic containers as per every ones economic status. The Kings and the affluent to use gold and silver containers.

STORAGE OF WATER IN COPPER VESSELS -

Acharyas have revered copper as an ideal container to positively charge water before drinking it. For thousands of years, the *Acharyas* would carry water in their copper pot called *'kamandalam'*. In traditional households in India, copper drinking vessels such as the ones offered here is still used. Ayurveda recommends storing water in Gold, Silver, Copper, Bronze vessels. Ayurveda has from times immemorial suggested using copper vessels to store water overnight and to drink this as soon as one gets up the next morning or use a copper pot to drink water from at all times. Copper has anti-microbial properties and can inhibit growth of harmful bacteria like *E.Coli* or *Staphylococcus aureus* which are viable on glass or stainless steel.

HEALTH BENEFITS OF DRINKING WATER STORED IN COPPER VESSELS -

It can prevent from amoebiasis, dyesentry, diarrhoea, cholera, jaundice and other water born diseases. Water stored in copper jug '*Tamra jal*' will regulate the fat & looses weight. Also

balances all the three *doshas* (Body humors- *Kapha Vata and Pitta*) and get rid of Piles, skin diseases, inflammation, respiratory disorders, spleen and gynaecological disorders.

Not only ancient Indians, the ancient Egyptians too used gold, silver and copper vessels and cutlery for the very purpose described above. The Egyptians knew that the three metals apart from their aesthetic use provided innumerable health benefits as well.

METAL CHARGED WATER -

Gold water, silver water, copper water means water charged with the healing qualities of these metals. It is known that copper, silver and gold have health benefits for the human body. These health benefits can be transferred to the water which comes in contact with these metals.

PROCEDURE FOR MAKING METAL CHARGED WATER -

- Wash the needed metal well with clean water.
- In a steel vessel (do not use aluminium vessel), put 4 to 5 cups of fresh & clean water. Drop all the metal in this water and keep the water for boiling. Keep boiling the water till 2 cups of water remain.
- Remove the metals from the water and strain this water through a fine muslin cloth.
- The resultant water is the metal charged water.
- Drink 1 cup of this slightly warm metal charged water in the morning and the other cup in the evening.

SOME HEALTH BENEFITS OF METAL CHARGED WATER -

Gold charged water

People suffering from respiratory disease like asthma, breathlessness, diseases of the lungs, heart diseases, brain diseases, find it benefits to consume gold charged water.

Gold benefits the brain, relaxes the body and mind. Cleopatra used it for its benefits to health and beauty. It is also used in China as medicine.

Silver charged water

People suffering from digestive problems and organs related to digestion like stomach, intestines, liver etc and those suffering from diseases of the urinary system and organs find it benefits to consume silver charged water.

Silver has anti bacterial, anti viral and anti fungal properties. In olden times milk was preserved by putting silver coins in it since it kills pathogens of all types instantly.

Copper charged water

Drinking water from copper vessels prevents ageing i.e.*vaya-sthapak*. Copper can destroy undesirable virus and bacteria

Those suffering from a number of chronic and complicated diseases like joint diseases, polio, leprosy, high blood pressure, knee pains, stress and mental tension, paralysis find it benefits to consume copper charged water.

Copper is needed by the body for various physiological functions like RBC synthesis, protein metabolism, enzyme activity and benefits the nervous and circulatory systems and bone health.

OLIGODYNAMIC EFFECT -

When copper dissolves in water, water becomes ionic (electrolyte) as can be ascertained by its pH measurement. That is the reason the micro-organisms get killed in such water. This is called the Oligodynamic effect.

Copper has proven to kill bacteria due to what is called the 'oligodynamic' effect. The oligodynamic effect (Greek oligos = few, dynamis = force) was discovered in 1893 by the Swiss KW Nägeli as a toxic effect of metal-ions on living cells, algae, moulds, spores, fungi, virus, prokaryotic and eukaryotic microorganisms, even in relatively low concentrations. This antimicrobial effect is shown by ions of: mercury, silver, copper, iron, lead, zinc, bismuth, gold, aluminum and other metals.

Certain metals such as copper are known to be far more poisonous to bacteria than others e.g. stainless steel or aluminum.

COPPER CORROSION –

Copper vessel gets dark stains with used in homes & are found to be coated with green colour. When copper reacts with water, atmospheric oxygen & carbon formation of basic copper carbonate takes place and due to this green colour coating appears. Corrosive phenomenon is responsible for the formation basic copper carbonate.

METHOD FOR CLEANING OF COPPER VESSELS -

The copper pot oxidizes with water and requires cleaning from time to time.

- Make a rudimentary paste out of flour, salt and vinegar. Stir this up and then apply it to the copper. The acid in the vinegar will begin to dissolve the tarnish immediately.
- Use lime/lemon juice to cleanse the copper cup.
- Use tamarind to cleanse the copper cup.

Since basic copper carbonate is basic in nature, it can be removed by tartaric acid present in tamarind or citric acid present in lemon.

LITERATURE REVIEW OF STAINLESS STEEL

In 1913, English metallurgist Harry Brearly, working on a project to improve rifle barrels, accidentally discovered that adding chromium to low carbon steel gives it stain resistance. In addition to iron, carbon and chromium, modern stainless steel may also contain other elements, such as nickel, niobium, molybdenum, and titanium. Nickel, molybdenum, niobium and chromium enhance the corrosion resistance of stainless steel.

It is the addition of a minimum of 12% chromium to the steel that makes it resist rust, or stain 'less' than other types of steel. The chromium in the steel combines with oxygen in the atmosphere to form a thin, invisible layer of chrome-containing oxide, called the passive film. The sizes of chromium atoms and their oxides are similar, so they pack neatly together on the surface of the metal, forming a stable layer only a few atoms thick.

If the metal is cut or scratched and the passive film is disrupted, more oxide will quickly form and recover the exposed surface, protecting it from oxidative corrosion. (Iron on the other hand, rusts quickly because atomic iron is much smaller than its oxide, so the oxide forms a loose rather than tightly-packed layer and flakes away.) The passive film requires oxygen to self-repair, so stainless steels have poor corrosion resistance in low-oxygen and poor circulation environments. In seawater, chlorides from the salt will attack and destroy the passive film more quickly than it can be repaired in a low oxygen environment.

Types of Stainless Steel

The three main types of stainless steels are austenitic, ferritic, and martensitic.
These three types of steels are identified by their microstructure or predominant crystal phase.

Austenitic:

Austenitic steels have austenite as their primary phase (face centered cubic crystal).
These are alloys containing chromium and nickel (sometimes manganese and nitrogen), structured around the Type 302 composition of iron, 18% chromium, and 8% nickel.

Austenitic steels are not hardenable by heat treatment. The most familiar stainless steel is probably Type 304, sometimes called T304 or simply 304. Type 304 surgical stainless steel is an austenitic steel containing 18-20% chromium and 8-10% nickel.

Ferritic:

Ferritic steels have ferrite (body centered cubic crystal) as their main phase. These steels contain iron and chromium, based on the Type 430 composition of 17% chromium. Ferritic steel is less ductile than austenitic steel and is not hardenable by heat treatment.

Martensitic:

The characteristic orthorhombic martensite microstructure was first observed by German microscopist Adolf Martens around 1890. Martensitic steels are low carbon steels built around the Type 410 composition of iron, 12% chromium, and 0.12% carbon. They may be tempered and hardened. Martensite gives steel great hardness, but it also reduces its toughness and makes it brittle, so few steels are fully hardened.

There are also other grades of stainless steels, such as precipitation-hardened, duplex, and cast stainless steels. Stainless steel can be produced in a variety of finishes and textures and can be tinted over a broad spectrum of colors.

Passivation

There is some dispute over whether the corrosion resistance of stainless steel can be enhanced by the process of passivation. Essentially, passivation is the removal of free iron from the surface of the steel. This is performed by immersing the steel in an oxidant, such as nitric acid or citric acid solution. Since the top layer of iron is removed, passivation diminishes surface discoloration.

While passivation does not affect the thickness or effectiveness of the passive layer, it is useful in producing a clean surface for a further treatment, such as plating or painting. On the other hand, if the oxidant is incompletely removed from the steel, as sometimes happens in pieces with tight joints or corners and then crevice corrosion may result.

Most research indicates that diminishing surface particle corrosion does not reduce susceptibility to pitting corrosion. The various grades of steel are used to resist corrosion from water, chlorine, acid and alkaline solutions, and chemicals. High-alloyed grades have heightened fire and heat resistance.

MATERIALS AND METHODS

A) MATERIALS -

I) Conceptual

II) Vessels

III) Water Sources

IV) Instrument

V) Other

I) CONCEPTUAL :

Literature source for the present study is obtained from Vedic scriptures, Classical texts of Ayurveda, Modern texts, Published articles, Research journals from various media like internet and followed by retrospective study of related research works.

II) VESSELS:

Tamra Vessel – 5 liter capacity.

Stainless Steel vessel- 5 liter capacity.

Both the vessels having water pot (*kalashi*) shaped & same volume. Both the Vessels are manufactured & purchased from Laxmi Metal, Chavadartale, Tambat Lane, Mahad, Dist Raigad

III) WATER SOURCES:

Raw water from selected sources i.e. River &Tube Well form Kodoli area.

IV) INSTRUMENTS:

i. Digital Nephelometer

ii. Laboratory Thermometer

iii. Instruments for EDTA Titration

iv. pH meter

v. Standard Glass fiber filter

vi. Evaporation Apparatus

vii. Instruments & reagents for MPN Method

The entire instruments are used at the laboratory of Environment Science Dept. Shivaji University Kolhapur.

V) OTHER:

Glass container & plastic container for sample collection. These containers were purchased from market.

B) METHODS –

1) Study Design

2) Sampling

3) Inclusion Criteria

4) Exclusion Criteria

5) Parameter for assessment

6) Criteria for assessment

7) Experimental Study

1) Study Design- Laboratorial Experimental Study:

This is the experimental study design. The Study is conducted on water samples of River & Tube Well only. *Tamra* & Stainless Steel vessels with lid having capacity of 5 liter water storage are taken for this study.

2) Sampling Procedure:

Collection of water is done from following two different most usable drinking water sources in Kodoli area according to The Gazetteer Department of Maharashtra - Directory of Villages- Directory 8 - Drinking Water Facilities..

i. River

ii Tube well

For the sample collection of river water River Warna is present in this area. Total 6 km. area of River Warana is comes under Kodoli Grampanchayat. Total twelve points having a distance of ½ km are taken into consideration for collection of water. Out of these twelve points six collection points of river are selected for random sample collection by draw method, with the hands of third party. These are as follows –

S1 - Near Kakhe Bridge ,S2 – Near Y. E. Patil Dag,S3 - Near V. K. Patil Dag,

S4 – Near Deshmukh Dag, S5 –Near Chikurde Bridge & S6 – Near Nilewadi Bridge.

This Draw process was done only to avoid the bias in study.

For the sample collection of Tube Well water total 92 Tube Wells are present in Kodoli Grampanchayat area. Out of these Tube wells 67 are in working position & 25 tube wells are in non working position. Therefore total 67 numbers of Tube Wells are taken into consideration for collection of water. Out of these six are selected for random sample collection by draw method, with the hands of third party. These are as follows –

S1 - Tube well No. 5, S2 - Tube well No. 26, S3 - Tube well No. 32,

S4 - Tube well No. 47, S5 - Tube well No. 58 & S6 - Tube well No. 61.

This Draw process was done only to avoid the bias in study.

3) Inclusion Criteria:

1. For Vessel: *Tamra* and Stainless Steel Vessels

Both vessels having Water Pot (*Kalashi*) shaped &

5 liter capacity volume and weight about 1kg.

2. For water: River & Tube Well these two sources are taken

4) Exclusion Criteria:

1. For Vessel: Other vessels mentioned by *Shushruta* in reference *Shloka*

2. For water: Other drinking water sources mentioned in *Samhitas.*

5) Parameter for Assessment:

1)Ayurvedic Parameter

i) *Gandha*

ii) *Shitata / Ushnata*

iii) *Shudhi (avilata)*

2) Modern Parameter

i) Physical :-

Colour

Odour

Turbidity

Temperature

ii) Chemical

Hardness

pH

Total Suspended Solids

Total Dissolved Solids

iii) Microbiological

Bacteriological indicator (MPN)

Assessment was done by following methods –

For Ayurvedic Parameter

Gandha :-	Subjective by *Ghranendriya* i.e. Smell of the water feel by nose
Shitata / Ushnata :-	Temperature sensed by the finger after dipping in water
Shudhi(Avilata) :-	Clarity of water i.e. Varna of the drinking water seen by naked eyes

For Modern Parameter

Colour : -	Visual test (Colour of water means seen by naked eyes)
Odour : -	Smell of the water feel by nose
Turbidity : -	Digital Nephelometer
Temperature :-	By Laboratory Thermometer
Hardness : -	EDTA (Ethylene diamine tetra acetic acid) Titration method.
pH :-	By pH meter
Total Suspended Solids (TSS):	By filtration of water sample through standard glass-fiber filter
Total Dissolved Solids (TDS):	By evaporation method
Bacteriological Indicator:-	MPN (Most Probable Number) by Multiple Tube Method Test is based on estimating the most probable number (MPN) of Coliform organisms in 100 ml of water . The test is carried out by inoculating measured quantities of the sample water 0.1,1.0,10,50 ml into tubes of McConkey's Lactose Bile Salt Broth with bromcresol purple as an indicator . The tubes are incubated for 48 hrs from number of tubes showing acid & gas an estimate of the MPN of coliform organism in 100ml of the sample water can be obtained from statistical tables. This result is known as presumptive coliform count.

During protocol submission for PhD, I was mentioned that, " If raw water MPN is nil in 100ml then Antimicrobial study of either sample will be done after contamination with Enteric Bacteria." But after testing the raw water in every season there was a presence of coliform bacteria in desirable amount, so there was no need to do artificial contamination of water with Enteric Bacteria.

6) Criteria for Assessment:

Assessment of water qualities of samples are done by comparison between water analysis laboratory results from both vessels as well as comparison with Indian Standard Specification for drinking water.

7) Experimental Study

For this present study the *Shad Rutus* (six seasons) according to text are defined as follows:

1. *Vasant Rutu* **–** 16th Feb to 15th April
2. *Greeshma Rutu* **–** 16th April to 15th June
3. *Varsha Rutu* – 16th June to 15th August
4. *Sharad Rutu* – 16th August to 15th October
5. *Hemant Rutu* – 16th October to 15th December
6. *Shishir Rutu* – 16th December to 15th February

At the time of present study in Kodoli observation shows that the seasons have considerably changed than text format of seasons and are as follows-

Vasant Rutu was seen at the time period from 16th Feb to 15th April 2012
Greeshma Rutu was seen elongated i.e. from 16th April to 23rd June 2012
Varsha Rutu was seen at the time period from 23rd June to 10th Sept 2012
Sharad Rutu was also seen elongated i.e. from 10th Sept to 15th Nov 2012
Hemant Rutu was seen at the time period from 16th Nov to 30th Dec 2012
Shishir Rutu was seen at the time period from 1st Jan to 15th Feb 2013

Collection of water sample was done as follows :
In *Vasanta rutu* – 1 March to 20March 2012
In *Grishma rutu* – 1May to 20 May 2012
In *Varsha rutu* – 18 July to 8 Aug 2012
In *Sharada rutu* - 1Oct to 20 Oct 2012
In *Hemanta rutu* - 2 Dec to 22 Dec 2012
In Shishir rutu - 18 January to 8 Feb 2013

Collection of One Sample from above mentioned each site of river & tube well is done in each *rutu.* i. e. six samples from each source of water in each *rutu.*

Laboratorial Preparation :

All the preparations about examination and analysis of the water samples was arranged day before of collection so that no time was lost bringing the water samples to the testing laboratory and analyzing them while collecting. For water sample all the care was taken to collect it in a sterile condition in case of doubt the samples were repeated.

Preparation of Vessel:

Tamra vessels were cleaned with tamarind carefully. After that washed with dish washing detergent. And Stainless Steel vessels were washed with dish washing detergent only. Both the vessels were dried by clean cloth then exposed to sunrays for 20 minutes. After this used for water storage. Procedure is done before every storage. In rainy season whenever sunrays are not available vessels rinsed by boiled water three times.

Collection method of water sample:

1) Raw water is collected from River & Tube well at 9.00 to 10.00 am every time.

2) Collection of River Water & Tube well water is done by following manner –

A) Collection Of Sample From River - Sample from river was collected 10 ft. from the bank.
B) Collection Of Sample From Tube well- While collecting **s**ample from Tube Well pumping was done and water was allowed to flow at least for 2 minutes in order to flush the interior of the nozzle & to discharge the stagnant water. The Plastic container / bottle was filled from a gentle stream of water from the tube well, avoiding splashing.

3) Labeling of certain particulars regarding the Date and Time of collection & dispatch, Source of water, Sample for Physical Chemical testing or For Bacteriological study, Vessel in which water to be stored was done throughout the study.

4) After collecting raw water samples, theses samples were immediately brought in to laboratory for the estimation of various Ayurvedic & physical - chemical – bacteriological parameters as per lab requirement. Every care was taken during the transport of sample.

A) For Physical & Chemical testing of raw water – Samples for Physical and Chemical examination was collected in the clean plastic can having 1 liter capacity. Before collecting the sample the can was rinsed three times with boiled water. Then filled with sample water, tied and sealed.

B) For Bacteriological testing of raw water – Samples for bacteriological examination was collected in clean sterilized bottles made of natural glass, of capacity 200-250 ml

5) Collection of water for the storage in *Tamra* & Stainless Steel Vessels

A) Water was collected in plastic can having a 10 lits capacity which is rinsed by boiled water three times.10 lits of sample from each source was collected in this plastic can which is immediately poured into both vessels (*Tamra* & Stainless Steel) 5 lits in each.

B) Storage of this water was done for 12 hrs 24 hrs & 48 hrs in each vessel. After 12 hrs 24 hrs & 48 hrs water was brought in to laboratory for testing. Adequate water sample was brought from vessels for testing. Same method of water collection was used which is mentioned above for Physical, Chemical & Bacteriological testing of raw water.

6) Total 6 samples are taken in each *rutu* from both the sources. Same procedure was done in every season (*Rutu*) according to Ayurveda i.e. *Varsha, Sharad, Hemant, Shishir , Vasant* & *Grishma.*

7) Total No. of Testing :

i) Raw water – 2 X 6 X 6 = 72

ii) *Tamra* Vessel storage – 2 X 6 X 6 X 3 = 216

iii) Stainless Steel Vessel storage – 2 X 6 X 6 X 3 = 216

Additional testing of one sample is done other than mentioned in Protocol. This is done with Purified water supplied by Grampanchayat in research area.

Also additional analysis of release of copper ion in water & quantity of copper in malachite (basic copper carbonate) was done for *Tamra* vessel.

8) All laboratory testing's are done at Environmental Science Dept. of Shivaji University Kolhapur

9) Observations are noted time to time. After completion of all water testing statistical analysis is done.

OBSERVATIONS AND RESULTS

RESEARCH HYPOTHESES ARE -

1) $\mathbf{H_0}$**:** Water stored in *Tamra* vessel does not show significant changes in its qualities

$\mathbf{H_1}$: Water stored in *Tamra* vessel shows significant changes in its qualities

2) $\mathbf{H_0}$**:** Water stored in Stainless Steel vessel does not show significant changes in its qualities

$\mathbf{H_1}$**:** Water stored in Stainless Steel vessel shows significant changes in its qualities

3) $\mathbf{H_0}$**:** Water stored in *Tamra* vessel does not show significant changes in its qualities than it stored in Stainless Steel vessel

$\mathbf{H_1}$**:** Water stored in *Tamra* vessel shows significant changes in its qualities than it stored in Stainless Steel vessel

STATISTICAL ANALYSIS

"Paired t test" has been used for objective parameters while for analysis of subjective parameters, "Wilcoxon signed rank test" (Ordinal data), "McNemar test" and "Pearson Chi-square test" (Dichotomous data) have been used.

Despite the third hypothesis aims at assessing between-group difference, as the design of study qualify pairing between the water sample stored in two vessels – Tamra and Stainless steel; both for intra-group (within-group) comparison and intergroup (between-group) comparison "Paired" tests have been used. Level of significance will be 5%

Baseline comparison of various parameters between raw water of river and tube well

1) OBJECTIVE PARAMETERS – *RUTU* WISE

Parameter	N	*Rutu*	Mean			d.f.	Unpaired 't' test	P-value
			River	Tube well	diff			
Turbidity	6	*Vasant*	3.733	2.850	0.883	10	22.00	< 0.001
	6	*Greeshma*	3.600	3.067	0.533	10	12.649	< 0.001
	6	*Varsha*	4.650	2.983	1.667	10	28.398	< 0.001
	6	*Sharad*	3.000	2.683	0.317	10	7.889	< 0.001
	6	*Hemant*	3.283	2.800	0.483	10	8.907	< 0.001
	6	*Shishir*	3.417	2.867	0.550	10	10.541	< 0.001
Temperature	6	*Vasant*	28.333	27.833	0.500	10	1.342	0.209
	6	*Greeshma*	31.333	30.667	0.667	10	1.414	0.188
	6	*Varsha*	27.667	27.000	0.667	10	2.000	0.073
	6	*Sharad*	28.333	28.000	0.333	10	0.598	0.563
	6	*Hemant*	26.500	25.833	0.667	10	1.754	0.110
	6	*Shishir*	26.667	26.167	0.500	10	1.342	0.209
Hardness	6	*Vasant*	305.000	438.000	-	10	-182.118	< 0.001
	6	*Greeshma*	299.833	425.167	-	10	-185.693	< 0.001
	6	*Varsha*	314.000	440.167	-	10	-232.511	< 0.001
	6	*Sharad*	252.500	334.833	-	10	-76.962	< 0.001
	6	*Hemant*	308.167	419.167	-	10	-69.893	< 0.001
	6	*Shishir*	309.833	435.333	-	10.0	-125.153	< 0.001
pH	6	*Vasant*	7.117	7.233	-0.117	10.0	2.004	0.073
	6	*Greeshma*	7.450	7.483	-0.033	10.0	0.632	0.541
	6	*Varsha*	6.783	6.967	-0.183	10.0	3.514	0.006
	6	*Sharad*	7.017	7.033	-0.017	10.0	0.447	0.664
	6	*Hemant*	7.167	7.167	0.000	10.0	0.000	1.000
	6	*Shishir*	7.067	7.183	-0.117	10.0	4.341	0.001
TSS	6	*Vasant*	9.117	6.883	2.233	10	39.344	< 0.001
	6	*Greeshma*	9.117	6.200	2.917	10	61.113	< 0.001
	6	*Varsha*	11.833	7.783	4.050	10	89.329	< 0.001
	6	*Sharad*	9.017	5.983	3.033	10	69.794	< 0.001
	6	*Hemant*	9.783	7.100	2.683	10	66.852	< 0.001
	6	*Shishir*	9.700	6.783	2.917	10	72.665	< 0.001
TDS	6	*Vasant*	222.000	366.833	-44.83	10	-266.911	< 0.001
	6	*Greeshma*	221.500	344.000	-	10	-245.000	< 0.001
	6	*Varsha*	279.833	397.833	-	10	-145.739	< 0.001
	6	*Sharad*	219.833	326.833	-	10	-188.498	< 0.001
	6	*Hemant*	234.000	335.500	-	10	-119.897	< 0.001
	6	*Shishir*	223.167	333.833	-	10	-153.140	< 0.001
MPN	6	*Vasant*	408.833	388.000	20.833	10	4.204	0.002
	6	*Greeshma*	449.833	413.167	36.667	10	4.670	0.001
	6	*Varsha*	583.833	492.833	91.000	10	10.760	< 0.001
	6	*Sharad*	219.000	210.000	9.000	10	2.535	0.030
	6	*Hemant*	395.000	394.000	1.000	10	0.484	0.639
	6	*Shishir*	392.167	388.833	3.333	10	1.743	0.112

Turbidity of raw water of river was higher than turbidity of raw water of tube well for all 6 *rutus* (all P-values < 0.001) at 5% level of significance.

In all *rutu*, there was no significant difference between temperature of river raw water and temperature of tube well raw water (all P-values > 0.05) at 5% level of significance.

Hardness for raw water of tube well was significantly higher than that of river water for each of 6 *rutus* (all P-value < 0.001).

For *Varsha* and *Shishir rutu*, pH of river raw water was significantly higher than that of tube well raw water (P-value < 0.05). For other *rutus- Vasant, Greeshma, Sharad* and *Hemant* pH of both sources were not significantly different at 5% level of significance.

Total Suspended Solids (TSS) for river raw water was higher than TSS for tube well raw water for all 6 *rutus* (all P-values < 0.001) at 5% level of significance.

Total Dissolved Solids (TDS) for raw water of tube well was significantly higher than that of river water for each of 6 *rutus* (all P-value < 0.001).

For *Vasant, Greeshma, Varsha* and *Sharad rutu,*Most Probable Number (MPN) for river raw water was significantly higher than that of tube well water (P-values = 0.002, 0.001, <0.001 and 0.030 respectively). For *Hemant* and *Shishir rutu,* the difference between MPN of two sources was insignificant at 5% level of significance.

2) OVERALL ANALYSIS OF OBJECTIVE PARAMETERS

Parameter	**N**	**Mean**			**d. f.**	**Unpaired 't' test**	**P-value**
		River	**Tube well**	**diff**			
Turbidity	36	3.614	2.875	0.739	70	8.037	< 0.001
Temperature	36	28.139	27.583	0.556	70.000	1.345	0.183
Hardness	36	298.222	415.444	-117.222	70	-16.366	< 0.001
pH	36	7.100	7.178	-0.078	70.000	1.667	0.100
TSS	36	9.761	6.789	2.972	70	15.386	< 0.001
TDS	36	233.389	350.806	-117.417	70	-21.366	< 0.001
MPN	36	408.111	381.139	26.972	70	1.164	0.248

There was significant difference between turbidity of river raw water and turbidity of tube well raw water (P-value < 0.001) at 5% level of significance.

Temperature of river raw water and that of tube well raw water was not significantly different (P-value < 0.183) at 5% level of significance.

Hardness of tube well raw water was significantly higher than that of river water (P-value < 0.001) at 5% level of significance.

pH of river raw water and tube well raw water was not significantly different (P-value = 0.100) at 5% level of significance.

TSS of river raw water is significantly higher than that of tube well raw water (P-value < 0.001) at 5% level of significance.

TDS of tube well raw water was significantly higher than that of river water (P-value < 0.001) at 5% level of significance.

There was no significant difference between MPN of river raw water and MPN of tube well raw water (P-value = 0.248) at 5% level of significance.

3) SUBJECTIVE PARAMETERS – *RUTU* WISE

Parameter	N	Rutu	Median			Mann-Whitney	P-value
			River	Tube well	diff		
Colour	6	*Vasant*	1	1	0	-	-
	6	*Greeshma*	2	1	1	36	0.001
	6	*Varsha*	3	2	1	36	0.001
	6	*Sharad*	1	1	0	-	-
	6	*Hemant*	1	1	0	-	-
	6	*Shishir*	1	1	0	-	-
Odour	6	*Vasant*	1	1	0	-	-
	6	*Greeshma*	1	1	0	-	-
	6	*Varsha*	1	1	0	-	-
	6	*Sharad*	1	1	0	-	-
	6	*Hemant*	1	1	0	-	-
	6	*Shishir*	1	1	0	-	-
Gandha	6	*Vasant*	1	1	0	-	-
	6	*Greeshma*	1	1	0	-	-
	6	*Varsha*	1	1	0	-	-
	6	*Sharad*	1	1	0	-	-
	6	*Hemant*	1	1	0	-	-
	6	*Shishir*	1	1	0	-	-
Shuddhi	6	*Vasant*	1	1	0	-	-
	6	*Greeshma*	2	1	1	36	0.001
	6	*Varsha*	3	2	1	36	0.001
	6	*Sharad*	1	1	0	-	-
	6	*Hemant*	1	1	0	-	-
	6	*Shishir*	1	1	0	-	-
Shitata	6	*Vasant*	3	2	1	36	0.001
	6	*Greeshma*	3	2	1	36	0.001
	6	*Varsha*	2	2	0	-	-
	6	*Sharad*	2	2	0	-	-
	6	*Hemant*	2	2	0	-	-
	6	*Shishir*	2	2	0	-	-

For *Greeshma* and *Varsha rutu,* the colour scores for river raw water was significantly higher than that of tube well water (P-values = 0.001 & 0.001 respectively) at 5% level of significance. For all other *rutus,* both the sources were having identical colour scores.

Odour scores for both the sources of water were identical for all 6 *rutus*.

Gandha scores for river sample and tube well sample was identical for all 6 *rutus.*

For *Greeshma* and *Varsha rutu,* the *Shuddhi* scores for river raw water was significantly higher than that of tube well raw water (P-values = 0.001 & 0.001 respectively) at 5% level of significance. For all other *rutus,* both the sources were having identical *Shuddhi* scores.

For *Vasant* and *Greeshma rutu,* the *Shitata* scores for river raw water was significantly higher than that of tube well water (P-values = 0.001 & 0.001 respectively) at 5% level of significance. For all other *rutus,* both the sources were having identical *Shitata* scores

2) OVERALL ANALYSIS OF SUBJECTIVE PARAMETERS

Parameter	**N**	**Median**			**Mann- Whitney U test**	**P-value**
		River	**Tube well**	**diff**		
Colour	36	1	1	0	774	0.062
Odour	36	1	1	0	-	-
Gandha	36	1	1	0	-	-
Shuddhi	36	1	1	0	774	0.062
Shitata	36	2	2	0	864	< 0.001

There was no significant difference with colour scores of river water and colour of tube well water (P-value = 0.062) at 5% level of significance.

Odour scores of raw water of river water and tube well were essentially equal.

Gandha scores of raw water of river water and tube well were essentially equal.

Shuddhi scores of raw water of river water and that of tube well was not significantly different (P-value = 0.062) at 5% level of significance.

Shitata scores of river raw water (Mean = 2.33, median = 2) was significantly higher than that of tube well water (mean = 2, median = 2) at 5% level of significance.

OBJECTIVE PARAMETER ANALYSIS - *RUTU* WISE

1) WITHIN GROUP EFFECT

i) Turbidity

a) Source – River Vessel - *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	3.733	3.617	0.117	0.041	0.017	7.000	0.001
	6	Raw – 24 Hr	3.733	3.550	0.183	0.075	0.031	5.966	0.002
	6	Raw – 48 Hr	3.733	3.500	0.233	0.103	0.042	5.534	0.003
Greeshma	6	Raw – 12 Hr	3.600	3.550	0.050	0.055	0.022	2.236	0.076
	6	Raw – 24 Hr	3.600	3.417	0.183	0.041	0.017	11.000	< 0.001
	6	Raw – 48 Hr	3.600	3.233	0.367	0.052	0.021	17.393	< 0.001
Varsha	6	Raw – 12 Hr	4.650	4.467	0.183	0.041	0.017	11.000	< 0.001
	6	Raw – 24 Hr	4.650	4.283	0.367	0.082	0.033	11.000	< 0.001
	6	Raw – 48 Hr	4.650	4.100	0.550	0.122	0.050	11.000	< 0.001
Sharad	6	Raw – 12 Hr	3.000	2.967	0.033	0.052	0.021	1.581	0.175
	6	Raw – 24 Hr	3.000	2.933	0.067	0.082	0.033	2.000	0.102
	6	Raw – 48 Hr	3.000	2.867	0.133	0.052	0.021	6.325	0.001
Hemant	6	Raw – 12 Hr	3.283	3.083	0.200	0.089	0.037	5.477	0.003
	6	Raw – 24 Hr	3.283	2.933	0.350	0.152	0.062	5.653	0.002
	6	Raw – 48 Hr	3.283	2.867	0.417	0.075	0.031	13.558	< 0.001
Shishir	6	Raw – 12 Hr	3.417	3.083	0.333	0.103	0.042	7.906	0.001
	6	Raw – 24 Hr	3.417	2.983	0.433	0.082	0.033	13.000	< 0.001
	6	Raw – 48 Hr	3.417	2.917	0.500	0.126	0.052	9.682	< 0.001

Source – River Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	3.733	3.633	0.100	0.063	0.026	3.873	0.012
	6	Raw – 24 Hr	3.733	3.567	0.167	0.052	0.021	7.906	0.001
	6	Raw – 48 Hr	3.733	3.500	0.233	0.082	0.033	7.000	0.001
Greeshma	6	Raw – 12 Hr	3.600	3.533	0.067	0.052	0.021	3.162	0.025
	6	Raw – 24 Hr	3.600	3.417	0.183	0.075	0.031	5.966	0.002
	6	Raw – 48 Hr	3.600	3.233	0.367	0.082	0.033	11.000	< 0.001
Varsha	6	Raw – 12 Hr	4.650	4.483	0.167	0.052	0.021	7.906	0.001
	6	Raw – 24 Hr	4.650	4.283	0.367	0.082	0.033	11.000	< 0.001
	6	Raw – 48 Hr	4.650	4.117	0.533	0.197	0.080	6.644	0.001
Sharad	6	Raw – 12 Hr	3.000	2.967	0.033	0.052	0.021	1.581	0.175
	6	Raw – 24 Hr	3.000	2.967	0.033	0.052	0.021	1.581	0.175
	6	Raw – 48 Hr	3.000	2.883	0.117	0.041	0.017	7.000	0.001
Hemant	6	Raw – 12 Hr	3.283	3.100	0.183	0.147	0.060	3.051	0.028
	6	Raw – 24 Hr	3.283	2.933	0.350	0.138	0.056	6.220	0.002
	6	Raw – 48 Hr	3.283	2.900	0.383	0.098	0.040	9.550	< 0.001
Shishir	6	Raw – 12 Hr	3.417	3.067	0.350	0.122	0.050	7.000	0.001
	6	Raw – 24 Hr	3.417	3.000	0.417	0.172	0.070	5.926	0.002
	6	Raw – 48 Hr	3.417	2.933	0.483	0.147	0.060	8.043	< 0.001

b) Source-Tube well Vessel - *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	2.850	2.750	0.100	0.063	0.026	3.873	0.012
	6	Raw – 24 Hr	2.850	2.717	0.133	0.082	0.033	4.000	0.010
	6	Raw – 48 Hr	2.850	2.667	0.183	0.098	0.040	4.568	0.006
Greeshma	6	Raw – 12 Hr	3.067	3.017	0.050	0.055	0.022	2.236	0.076
	6	Raw – 24 Hr	3.067	2.950	0.117	0.041	0.017	7.000	0.001
	6	Raw – 48 Hr	3.067	2.950	0.117	0.041	0.017	7.000	0.001
Varsha	6	Raw – 12 Hr	2.983	2.950	0.033	0.052	0.021	1.581	0.175
	6	Raw – 24 Hr	2.983	2.950	0.033	0.052	0.021	1.581	0.175
	6	Raw – 48 Hr	2.983	2.917	0.067	0.052	0.021	3.162	0.025
Sharad	6	Raw – 12 Hr	2.683	2.550	0.133	0.052	0.021	6.325	0.001
	6	Raw – 24 Hr	2.683	2.500	0.183	0.041	0.017	11.000	< 0.001
	6	Raw – 48 Hr	2.683	2.467	0.217	0.075	0.031	7.050	0.001
Hemant	6	Raw – 12 Hr	2.800	2.700	0.100	0.063	0.026	3.873	0.012
	6	Raw – 24 Hr	2.800	2.550	0.250	0.084	0.034	7.319	0.001
	6	Raw – 48 Hr	2.800	2.467	0.333	0.082	0.033	10.000	< 0.001
Shishir	6	Raw – 12 Hr	2.867	2.800	0.067	0.052	0.021	3.162	0.025
	6	Raw – 24 Hr	2.867	2.733	0.133	0.052	0.021	6.325	0.001
	6	Raw – 48 Hr	2.867	2.633	0.233	0.052	0.021	11.068	< 0.001

Source Tube well Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	2.850	2.767	0.083	0.075	0.031	2.712	0.042
	6	Raw – 24 Hr	2.850	2.717	0.133	0.052	0.021	6.325	0.001
	6	Raw – 48 Hr	2.850	2.683	0.167	0.052	0.021	7.906	0.001
Greeshma	6	Raw – 12 Hr	3.067	3.017	0.050	0.055	0.022	2.236	0.076
	6	Raw – 24 Hr	3.067	2.967	0.100	0.000	0.000	-	-
	6	Raw – 48 Hr	3.067	2.950	0.117	0.041	0.017	7.000	0.001
Varsha	6	Raw – 12 Hr	2.983	2.967	0.017	0.041	0.017	1.000	0.363
	6	Raw – 24 Hr	2.983	2.967	0.017	0.041	0.017	1.000	0.363
	6	Raw – 48 Hr	2.983	2.917	0.067	0.052	0.021	3.162	0.025
Sharad	6	Raw – 12 Hr	2.683	2.567	0.117	0.041	0.017	7.000	0.001
	6	Raw – 24 Hr	2.683	2.500	0.183	0.075	0.031	5.966	0.002
	6	Raw – 48 Hr	2.683	2.467	0.217	0.041	0.017	13.000	< 0.001
Hemant	6	Raw – 12 Hr	2.800	2.700	0.100	0.063	0.026	3.873	0.012
	6	Raw – 24 Hr	2.800	2.567	0.233	0.082	0.033	7.000	0.001
	6	Raw – 48 Hr	2.800	2.483	0.317	0.075	0.031	10.304	< 0.001
Shishir	6	Raw – 12 Hr	2.867	2.800	0.067	0.052	0.021	3.162	0.025
	6	Raw – 24 Hr	2.867	2.750	0.117	0.075	0.031	3.796	0.013
	6	Raw – 48 Hr	2.867	2.633	0.233	0.052	0.021	11.068	< 0.001

a) Source – River Vessel - *Tamra*

For River samples, at each *rutu – Vasant, Varsha, Hemant* and *Shishir* water stored in *Tamra* vessel showed significant reduction in turbidity at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05) while for *Sharad rutu*, the reduction in turbidity for time interval Raw – 12 Hr & Raw – 24 Hr was insignificant (both P-values = 0.175 & 0.102 respectively) and significant for time interval Raw – 48 Hr (P-value = 0.001). For *Greeshma rutu*, the reduction was insignificant for time interval Raw – 12 Hr (P-value = 0.076) while for subsequent intervals it showed significant reduction in turbidity (both P-values < 0.001).

Source – River Vessel - Stainless steel

Also, river water stored in Stainless steel vessel showed significant reduction in turbidity for *rutus – Vasant, Greeshma, Varsha, Hemant, Shishir* at every time interval Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). But for *Sharad rutu*, the reduction during time intervals Raw – 12 Hr and Raw – 24 Hrs was insignificant (both P-value = 0.175) and reduction during time interval Raw – 48 Hr was significant (P – value = 0.001) at 5% level of significance.

b) Source-Tube well Vessel - *Tamra*

For tube well samples, for *rutu – Vasant, Sharad, Hemant* and *Shishir*, water stored in *Tamra* vessel showed significant reduction in turbidity at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05) . For *Varsha rutu*, the reduction during time intervals Raw – 12 Hr and Raw – 24 Hrs was insignificant (both P-value = 0.175) and reduction during time interval Raw – 48 Hr was significant (P – value = 0.025) at 5% level of significance. For *Ggreeshma rutu*, the reduction was insignificant for time interval Raw – 12 Hr (P-value = 0.076) while for subsequent intervals it showed significant reduction in turbidity (both P-values = 0.001).

Source Tube well Vessel - Stainless steel

Also, tube well water stored in Stainless steel vessel showed significant reduction in turbidity for *rutus – Vasant, Sharad, Hemant, Shishir* at every time interval. For *Varsha rutu*, the reduction during time intervals Raw – 12 Hr and Raw – 24 Hrs was insignificant (P-value = 0.363 & 0.363 respectively) and reduction during time interval Raw – 48 Hr was significant (P – value = 0.025) at 5% level of significance. For *Greeshma rutu*, the reduction was insignificant for time interval Raw – 12 Hr (P-value = 0.076) while for subsequent intervals it showed significant reduction in turbidity (both P-values = 0.001).

ii) Temperature

a) Source –River Vessel - *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	28.333	26.833	1.500	0.548	0.224	6.708	0.001
	6	Raw – 24 Hr	28.333	28.500	-0.167	0.753	0.307	-0.542	0.611
	6	Raw – 48 Hr	28.333	29.500	-1.167	0.753	0.307	-3.796	0.013
Greeshma	6	Raw – 12 Hr	31.333	31.000	0.333	0.516	0.211	1.581	0.175
	6	Raw – 24 Hr	31.333	31.167	0.167	0.753	0.307	0.542	0.611
	6	Raw – 48 Hr	31.333	31.500	-0.167	0.753	0.307	-0.542	0.611
Varsha	6	Raw – 12 Hr	27.667	26.667	1.000	0.000	0.000	-	-
	6	Raw – 24 Hr	27.667	26.333	1.333	0.516	0.211	6.325	0.001
	6	Raw – 48 Hr	27.667	25.667	2.000	0.632	0.258	7.746	0.001
Sharad	6	Raw – 12 Hr	28.333	27.333	1.000	0.000	0.000	-	-
	6	Raw – 24 Hr	28.333	28.167	0.167	0.753	0.307	0.542	0.611
	6	Raw – 48 Hr	28.333	28.833	-0.500	1.049	0.428	-1.168	0.296
Hemant	6	Raw – 12 Hr	26.500	25.833	0.667	0.516	0.211	3.162	0.025
	6	Raw – 24 Hr	26.500	25.500	1.000	0.632	0.258	3.873	0.012
	6	Raw – 48 Hr	26.500	25.000	1.500	0.548	0.224	6.708	0.001
Shishir	6	Raw – 12 Hr	26.667	26.333	0.333	0.516	0.211	1.581	0.175
	6	Raw – 24 Hr	26.667	26.167	0.500	0.548	0.224	2.236	0.076
	6	Raw – 48 Hr	26.667	25.333	1.333	0.516	0.211	6.325	0.001

Source - River Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	28.333	27.167	1.167	0.408	0.167	7.000	0.001
	6	Raw – 24 Hr	28.333	28.833	-0.500	0.837	0.342	-1.464	0.203
	6	Raw – 48 Hr	28.333	29.500	-1.167	0.408	0.167	-7.000	0.001
Greeshma	6	Raw – 12 Hr	31.333	31.000	0.333	0.516	0.211	1.581	0.175
	6	Raw – 24 Hr	31.333	31.333	0.000	0.632	0.258	0.000	1.000
	6	Raw – 48 Hr	31.333	31.667	-0.333	0.816	0.333	-1.000	0.363
Varsha	6	Raw – 12 Hr	27.667	27.167	0.500	0.548	0.224	2.236	0.076
	6	Raw – 24 Hr	27.667	26.500	1.167	0.408	0.167	7.000	0.001
	6	Raw – 48 Hr	27.667	26.000	1.667	0.816	0.333	5.000	0.004
Sharad	6	Raw – 12 Hr	28.333	27.833	0.500	0.548	0.224	2.236	0.076
	6	Raw – 24 Hr	28.333	28.500	-0.167	0.753	0.307	-0.542	0.611
	6	Raw – 48 Hr	28.333	29.333	-1.000	0.894	0.365	-2.739	0.041
Hemant	6	Raw – 12 Hr	26.500	25.833	0.667	0.516	0.211	3.162	0.025
	6	Raw – 24 Hr	26.500	25.667	0.833	0.753	0.307	2.712	0.042
	6	Raw – 48 Hr	26.500	25.167	1.333	0.516	0.211	6.325	0.001
Shishir	6	Raw – 12 Hr	26.667	26.333	0.333	0.516	0.211	1.581	0.175
	6	Raw – 24 Hr	26.667	26.167	0.500	0.548	0.224	2.236	0.076
	6	Raw – 48 Hr	26.667	25.500	1.167	0.753	0.307	3.796	0.013

b) Source-Tube well Vessel - Tamra

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	27.833	26.667	1.167	0.408	0.167	7.000	0.001
	6	Raw – 24 Hr	27.833	28.000	-0.167	0.408	0.167	-1.000	0.363
	6	Raw – 48 Hr	27.833	29.000	-1.167	0.408	0.167	-7.000	0.001
Greeshma	6	Raw – 12 Hr	30.667	30.167	0.500	0.548	0.224	2.236	0.076
	6	Raw – 24 Hr	30.667	30.500	0.167	0.408	0.167	1.000	0.363
	6	Raw – 48 Hr	30.667	30.333	0.333	0.516	0.211	1.581	0.175
Varsha	6	Raw – 12 Hr	27.000	25.833	1.167	0.408	0.167	7.000	0.001
	6	Raw – 24 Hr	27.000	25.500	1.500	0.837	0.342	4.392	0.007
	6	Raw – 48 Hr	27.000	24.833	2.167	0.408	0.167	13.000	< 0.001
Sharad	6	Raw – 12 Hr	28.000	26.833	1.167	0.753	0.307	3.796	0.013
	6	Raw – 24 Hr	28.000	27.667	0.333	0.516	0.211	1.581	0.175
	6	Raw – 48 Hr	28.000	28.167	-0.167	0.408	0.167	-1.000	0.363
Hemant	6	Raw – 12 Hr	25.833	25.167	0.667	0.516	0.211	3.162	0.025
	6	Raw – 24 Hr	25.833	25.000	0.833	0.983	0.401	2.076	0.093
	6	Raw – 48 Hr	25.833	24.667	1.167	0.983	0.401	2.907	0.034
Shishir	6	Raw – 12 Hr	26.167	25.500	0.667	0.516	0.211	3.162	0.025
	6	Raw – 24 Hr	26.167	25.333	0.833	0.983	0.401	2.076	0.093
	6	Raw – 48 Hr	26.167	24.833	1.333	0.516	0.211	6.325	0.001

Source Tube well Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	27.833	26.833	1.000	0.000	0.000	-	-
	6	Raw – 24 Hr	27.833	28.167	-0.333	0.516	0.211	-1.581	0.175
	6	Raw – 48 Hr	27.833	29.333	-1.500	0.548	0.224	-6.708	0.001
Greeshma	6	Raw – 12 Hr	30.667	30.333	0.333	0.516	0.211	1.581	0.175
	6	Raw – 24 Hr	30.667	30.500	0.167	0.408	0.167	1.000	0.363
	6	Raw – 48 Hr	30.667	30.500	0.167	0.753	0.307	0.542	0.611
Varsha	6	Raw – 12 Hr	27.000	26.000	1.000	0.000	0.000	-	-
	6	Raw – 24 Hr	27.000	25.667	1.333	0.816	0.333	4.000	0.010
	6	Raw – 48 Hr	27.000	25.167	1.833	0.753	0.307	5.966	0.002
Sharad	6	Raw – 12 Hr	28.000	27.167	0.833	0.408	0.167	5.000	0.004
	6	Raw – 24 Hr	28.000	28.000	0.000	0.632	0.258	0.000	1.000
	6	Raw – 48 Hr	28.000	28.500	-0.500	0.548	0.224	-2.236	0.076
Hemant	6	Raw – 12 Hr	25.833	25.333	0.500	0.548	0.224	2.236	0.076
	6	Raw – 24 Hr	25.833	25.000	0.833	0.753	0.307	2.712	0.042
	6	Raw – 48 Hr	25.833	24.833	1.000	0.894	0.365	2.739	0.041
Shishir	6	Raw – 12 Hr	26.167	25.833	0.333	0.816	0.333	1.000	0.363
	6	Raw – 24 Hr	26.167	25.667	0.500	0.837	0.342	1.464	0.203
	6	Raw – 48 Hr	26.167	25.000	1.167	0.753	0.307	3.796	0.013

a) Source –River Vessel - *Tamra*

For river sample, water stored in *Tamra* vessel showed significant reduction in temperature for all time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (All P-values < 0.05) for *rutus Hemant* and *Varsha.* For *Greeshma rutu*, there was no significant change in the temperature during any time interval (all P-value > 0.05). For *Vasant rutu,* temperature reduced significantly during time interval Raw – 12 Hr (P-value = 0.001) while increased significantly during time interval Raw – 48 Hr (P-value -0.013). The change in temperature during time interval Raw – 24 was insignificant (P-value = 0.611). There was significant reduction in temperature in *Sharad rutu* for time period Raw – 12 Hr, but for subsequent time period, there was no significant change in temperature (P-values > 0.05). In *Shishir rutu*, there was no significant reduction in temperature during time interval Raw – 12 Hr and Raw – 24 Hr but for time interval Raw – 48 Hr, there was significant reduction observed (P-value = 0.001).

Source - River Vessel - Stainless steel

For river sample, water stored in stainless steel vessel showed significant reduction in temperature for *Hemant rutu* in all time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (All P-values < 0.05). For *Greeshma rutu,* there was no significant change in the temperature during any time interval (all P-value > 0.05). For *Varsha rutu*, the reduction in temperature is insignificant for time interval Raw -12 Hr but subsequent time intervals showed significant reduction (P-values = 0.001 & 0.004 respectively). For *Vasant rutu,* temperature reduced significantly during time interval Raw – 12 Hr (P-value = 0.001) while increased significantly during time interval Raw – 48 Hr (P-value -0.001, change in temperature during time interval Raw – 24 being insignificant (P-value = 0.203). There was no significant changes in temperature in *Sharad rutu* for time period Raw – 12 Hr and Raw – 24 Hr (P-values > 0.05) but for time interval Raw – 48 Hr, the temperature increased significantly (P-values = 0.041). In *Shishir rutu*, there was no significant reduction in temperature during time interval Raw – 12 Hr and Raw – 24 Hr (P-values > 0.05) but for time interval Raw – 48 Hr, there was significant reduction observed (P-value = 0.013).

b) Source-Tube well Vessel - *Tamra*

For tube well sample, water stored in *Tamra* vessel showed significant reduction in temperature for all time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (All P-values < 0.05) for *Varsha rutu.* For *Greeshma rutu,* there was no significant change in the temperature

during any time interval (all P-value > 0.05). For *Vasant rutu*, temperature reduced significantly during time interval Raw – 12 Hr (P-value = 0.001) while increased significantly during time interval Raw – 48 Hr (P-value -0.001). The change in temperature during time interval Raw – 24 was insignificant (P-value = 0.363). There was significant reduction in temperature in *Sharad rutu* for time period Raw – 12 Hr, but for subsequent time period, there was no significant change in temperature (P-values > 0.05). In *Hemant and Shishir rutu*, there was significant reduction in temperature during time interval Raw – 12 Hr and Raw 48 Hr, but for time interval Raw – 24 Hr, there was no significant reduction in temperature (P-values = 0.093 & 0.093 respectively).

Source Tube well Vessel - Stainless steel

For tube well sample, water stored in stainless steel vessel showed significant reduction in temperature for *Varsha rutu* in all time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (All P-values < 0.05). For *Greeshma rutu*, there was no significant change in the temperature during any time interval (all P-value > 0.05). For *Hemant rutu*, temperature reduced significantly during time interval Raw – 24 Hr and Raw – 48 Hr while there was no significant change in temperature for time intervals Raw – 12 Hr. For *Vasant rutu*, temperature reduced significantly during time interval Raw – 12 Hr and Raw – 48 Hr (P-value = 0.001) while the change in temperature during time interval 24 Hr was insignificant (P-value = 0.175).There was significant reduction in temperature in *Sharad rutu* for time period Raw – 12 Hr but for time intervals Raw – 24 Hr and Raw – 48 Hr, the change in temperature isn't significant. In *Shishir rutu*, there was no significant reduction in temperature during time interval Raw – 12 Hr and Raw – 24 Hr (P-values > 0.05) but for time interval Raw – 48 Hr, there was significant reduction observed (P-value = 0.013).

iii) Hardness

a) Source –River Vessel – *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	Diff				
Vasant	6	Raw – 12 Hr	305.000	300.500	4.500	1.049	0.428	10.510	< 0.001
	6	Raw – 24 Hr	305.000	296.333	8.667	0.516	0.211	41.110	< 0.001
	6	Raw – 48 Hr	305.000	291.667	13.333	0.816	0.333	40.000	< 0.001
Greeshma	6	Raw – 12 Hr	299.833	295.833	4.000	0.000	0.000	-	-
	6	Raw – 24 Hr	299.833	292.000	7.833	0.753	0.307	25.489	< 0.001
	6	Raw – 48 Hr	299.833	288.667	11.167	0.753	0.307	36.336	< 0.001
Varsha	6	Raw – 12 Hr	314.000	310.500	3.500	0.548	0.224	15.652	< 0.001
	6	Raw – 24 Hr	314.000	307.500	6.500	1.049	0.428	15.181	< 0.001
	6	Raw – 48 Hr	314.000	304.333	9.667	1.211	0.494	19.552	< 0.001
Sharad	6	Raw – 12 Hr	252.500	249.167	3.333	1.033	0.422	7.906	0.001
	6	Raw – 24 Hr	252.500	244.833	7.667	1.033	0.422	18.183	< 0.001
	6	Raw – 48 Hr	252.500	242.000	10.500	1.049	0.428	24.523	< 0.001
Hemant	6	Raw – 12 Hr	308.167	304.833	3.333	0.816	0.333	10.000	< 0.001
	6	Raw – 24 Hr	308.167	301.000	7.167	0.983	0.401	17.855	< 0.001
	6	Raw – 48 Hr	308.167	297.333	10.833	0.753	0.307	35.251	< 0.001
Shishir	6	Raw – 12 Hr	309.833	306.833	3.000	0.632	0.258	11.619	< 0.001
	6	Raw – 24 Hr	309.833	303.833	6.000	0.894	0.365	16.432	< 0.001
	6	Raw – 48 Hr	309.833	300.667	9.167	0.753	0.307	29.828	< 0.001

Source - River Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	305.000	301.500	3.500	1.049	0.428	8.174	< 0.001
	6	Raw – 24 Hr	305.000	297.667	7.333	1.366	0.558	13.148	< 0.001
	6	Raw – 48 Hr	305.000	296.167	8.833	1.472	0.601	14.700	< 0.001
Greeshma	6	Raw – 12 Hr	299.833	297.500	2.333	0.816	0.333	7.000	0.001
	6	Raw – 24 Hr	299.833	295.833	4.000	1.673	0.683	5.855	0.002
	6	Raw – 48 Hr	299.833	294.167	5.667	1.506	0.615	9.220	< 0.001
Varsha	6	Raw – 12 Hr	314.000	310.833	3.167	0.753	0.307	10.304	< 0.001
	6	Raw – 24 Hr	314.000	308.500	5.500	1.049	0.428	12.845	< 0.001
	6	Raw – 48 Hr	314.000	307.833	6.167	0.753	0.307	20.066	< 0.001
Sharad	6	Raw – 12 Hr	252.500	250.333	2.167	0.408	0.167	13.000	< 0.001
	6	Raw – 24 Hr	252.500	248.000	4.500	0.837	0.342	13.175	< 0.001
	6	Raw – 48 Hr	252.500	247.167	5.333	1.033	0.422	12.649	< 0.001
Hemant	6	Raw – 12 Hr	308.167	305.833	2.333	1.033	0.422	5.534	0.003
	6	Raw – 24 Hr	308.167	304.167	4.000	1.265	0.516	7.746	0.001
	6	Raw – 48 Hr	308.167	303.000	5.167	0.983	0.401	12.872	0.001
Shishir	6	Raw – 12 Hr	309.833	307.833	2.000	0.632	0.258	7.746	< 0.001
	6	Raw – 24 Hr	309.833	306.167	3.667	1.033	0.422	8.696	< 0.001
	6	Raw – 48 Hr	309.833	304.833	5.000	0.894	0.365	13.693	< 0.001

b) Source-Tube well Vessel - *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	438.000	435.500	2.500	0.548	0.224	11.180	< 0.001
	6	Raw – 24 Hr	438.000	433.667	4.333	1.033	0.422	10.277	< 0.001
	6	Raw – 48 Hr	438.000	430.500	7.500	1.049	0.428	17.516	< 0.001
Greeshma	6	Raw – 12 Hr	425.167	423.167	2.000	0.632	0.258	7.746	0.001
	6	Raw – 24 Hr	425.167	421.000	4.167	1.329	0.543	7.679	0.001
	6	Raw – 48 Hr	425.167	417.500	7.667	0.816	0.333	23.000	< 0.001
Varsha	6	Raw – 12 Hr	440.167	438.000	2.167	0.408	0.167	13.000	< 0.001
	6	Raw – 24 Hr	440.167	434.833	5.333	1.033	0.422	12.649	< 0.001
	6	Raw – 48 Hr	440.167	432.333	7.833	1.472	0.601	13.035	< 0.001
Sharad	6	Raw – 12 Hr	334.833	331.667	3.167	0.753	0.307	10.304	< 0.001
	6	Raw – 24 Hr	334.833	329.333	5.500	1.049	0.428	12.845	< 0.001
	6	Raw – 48 Hr	334.833	327.000	7.833	0.753	0.307	25.489	< 0.001
Hemant	6	Raw – 12 Hr	419.167	416.500	2.667	0.516	0.211	12.649	< 0.001
	6	Raw – 24 Hr	419.167	413.667	5.500	0.548	0.224	24.597	< 0.001
	6	Raw – 48 Hr	419.167	411.000	8.167	0.753	0.307	26.574	< 0.001
Shishir	6	Raw – 12 Hr	435.333	432.833	2.500	0.548	0.224	11.180	< 0.001
	6	Raw – 24 Hr	435.333	430.333	5.000	1.265	0.516	9.682	0.001
	6	Raw – 48 Hr	435.333	428.000	7.333	2.503	1.022	7.176	< 0.001

Source Tube well Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	438.000	437.000	1.000	0.632	0.258	3.873	0.012
	6	Raw – 24 Hr	438.000	435.667	2.333	0.516	0.211	11.068	< 0.001
	6	Raw – 48 Hr	438.000	433.167	4.833	1.169	0.477	10.127	< 0.001
Greeshma	6	Raw – 12 Hr	425.167	424.167	1.000	0.632	0.258	3.873	0.012
	6	Raw – 24 Hr	425.167	422.500	2.667	0.816	0.333	8.000	< 0.001
	6	Raw – 48 Hr	425.167	420.500	4.667	0.816	0.333	14.000	< 0.001
Varsha	6	Raw – 12 Hr	440.167	439.000	1.167	0.408	0.167	7.000	0.001
	6	Raw – 24 Hr	440.167	436.833	3.333	0.816	0.333	10.000	< 0.001
	6	Raw – 48 Hr	440.167	434.333	5.833	0.983	0.401	14.533	< 0.001
Sharad	6	Raw – 12 Hr	334.833	333.667	1.167	0.753	0.307	3.796	0.013
	6	Raw – 24 Hr	334.833	331.333	3.500	1.049	0.428	8.174	< 0.001
	6	Raw – 48 Hr	334.833	329.500	5.333	1.211	0.494	10.787	< 0.001
Hemant	6	Raw – 12 Hr	419.167	417.667	1.500	0.548	0.224	6.708	0.001
	6	Raw – 24 Hr	419.167	415.833	3.333	1.033	0.422	7.906	0.001
	6	Raw – 48 Hr	419.167	413.500	5.667	0.516	0.211	26.879	0.001
Shishir	6	Raw – 12 Hr	435.333	433.833	1.500	0.548	0.224	6.708	< 0.001
	6	Raw – 24 Hr	435.333	432.333	3.000	0.894	0.365	8.216	< 0.001
	6	Raw – 48 Hr	435.333	430.333	5.000	1.095	0.447	11.180	0.012

a) Source –River Vessel – *Tamra*

For River samples, at every *rutu* of – *Vasant, Greeshma, Varsha, Sharad, Hemant* and *Shishir* water stored in *Tamra* vessel showed significant reduction in hardness at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

Source - River Vessel - Stainless steel

Also, water stored in Stainless steel vessel showed significant reduction in hardness at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05) for all *rutu.*

b) Source-Tube well Vessel - *Tamra*

For Tube well samples, at every *rutu* of – *Vasant, Greeshma, Varsha, Sharad, Hemant* and *Shishir,* water stored in Tamra vessel showed significant reduction in hardness at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

Source Tube well Vessel - Stainless steel

Also, water stored in Stainless steel vessel showed significant reduction in hardness at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05) for all *rutu*.

iv) pH

c) Source –River Vessel – *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	7.117	7.183	-	0.103	0.042	-1.581	0.175
	6	Raw – 24 Hr	7.117	7.317	-	0.110	0.045	-4.472	0.007
	6	Raw – 48 Hr	7.117	7.367	-	0.084	0.034	-7.319	0.001
Greeshma	6	Raw – 12 Hr	7.450	7.533	-	0.075	0.031	-2.712	0.042
	6	Raw – 24 Hr	7.450	7.633	-	0.075	0.031	-5.966	0.002
	6	Raw – 48 Hr	7.450	7.683	-	0.103	0.042	-5.534	0.003
Varsha	6	Raw – 12 Hr	6.783	6.900	-	0.075	0.031	-3.796	0.013
	6	Raw – 24 Hr	6.783	6.950	-	0.082	0.033	-5.000	0.004
	6	Raw – 48 Hr	6.783	7.117	-	0.052	0.021	-15.811	< 0.001
Sharad	6	Raw – 12 Hr	7.017	7.083	-	0.052	0.021	-3.162	0.025
	6	Raw – 24 Hr	7.017	7.117	-	0.000	0.000	-5340	< 0.001
	6	Raw – 48 Hr	7.017	7.167	-	0.055	0.022	-6.708	0.001
Hemant	6	Raw – 12 Hr	7.167	7.250	-	0.041	0.017	-5.000	0.004
	6	Raw – 24 Hr	7.167	7.317	-	0.055	0.022	-6.708	0.001
	6	Raw – 48 Hr	7.167	7.350	-	0.041	0.017	-11.000	< 0.001
Shishir	6	Raw – 12 Hr	7.067	7.167	-	0.063	0.026	-3.873	0.012
	6	Raw – 24 Hr	7.067	7.300	-	0.082	0.033	-7.000	0.001
	6	Raw – 48 Hr	7.067	7.467	-	0.089	0.037	-10.954	< 0.001

Source River Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	7.117	7.167	-0.050	0.105	0.043	-1.168	0.296
	6	Raw – 24 Hr	7.117	7.300	-0.183	0.098	0.040	-4.568	0.006
	6	Raw – 48 Hr	7.117	7.350	-0.233	0.082	0.033	-7.000	0.001
Greeshma	6	Raw – 12 Hr	7.450	7.500	-0.050	0.055	0.022	-2.236	0.076
	6	Raw – 24 Hr	7.450	7.617	-0.167	0.052	0.021	-7.906	0.001
	6	Raw – 48 Hr	7.450	7.650	-0.200	0.063	0.026	-7.746	0.001
Varsha	6	Raw – 12 Hr	6.783	6.883	-0.100	0.063	0.026	-3.873	0.012
	6	Raw – 24 Hr	6.783	6.950	-0.167	0.082	0.033	-5.000	0.004
	6	Raw – 48 Hr	6.783	7.100	-0.317	0.075	0.031	-10.304	< 0.001
Sharad	6	Raw – 12 Hr	7.017	7.050	-0.033	0.052	0.021	-1.581	0.175
	6	Raw – 24 Hr	7.017	7.100	-0.083	0.041	0.017	-5.000	0.004
	6	Raw – 48 Hr	7.017	7.133	-0.117	0.075	0.031	-3.796	0.013
Hemant	6	Raw – 12 Hr	7.167	7.233	-0.067	0.052	0.021	-3.162	0.025
	6	Raw – 24 Hr	7.167	7.300	-0.133	0.052	0.021	-6.325	0.001
	6	Raw – 48 Hr	7.167	7.350	-0.183	0.041	0.017	-11.000	< 0.001
Shishir	6	Raw – 12 Hr	7.067	7.183	-0.117	0.041	0.017	-7.000	0.001
	6	Raw – 24 Hr	7.067	7.283	-0.217	0.075	0.031	-7.050	0.001
	6	Raw – 48 Hr	7.067	7.433	-0.367	0.121	0.049	-7.416	0.001

b) Source – Tube well Vessel– *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	7.233	7.333	-0.100	0.063	0.026	-3.873	0.012
	6	Raw – 24 Hr	7.233	7.417	-0.183	0.075	0.031	-5.966	0.002
	6	Raw – 48 Hr	7.233	7.483	-0.250	0.055	0.022	-11.180	< 0.001
Greeshma	6	Raw – 12 Hr	7.483	7.567	-0.083	0.041	0.017	-5.000	0.004
	6	Raw – 24 Hr	7.483	7.667	-0.183	0.098	0.040	-4.568	0.006
	6	Raw – 48 Hr	7.483	7.733	-0.250	0.055	0.022	-11.180	< 0.001
Varsha	6	Raw – 12 Hr	6.967	7.033	-0.067	0.052	0.021	-3.162	0.025
	6	Raw – 24 Hr	6.967	7.117	-0.150	0.084	0.034	-4.392	0.007
	6	Raw – 48 Hr	6.967	7.183	-0.217	0.075	0.031	-7.050	0.001
Sharad	6	Raw – 12 Hr	7.033	7.067	-0.033	0.052	0.021	-1.581	0.175
	6	Raw – 24 Hr	7.033	7.067	-0.033	0.052	0.021	-1.581	0.175
	6	Raw – 48 Hr	7.033	7.117	-0.083	0.098	0.040	-2.076	0.093
Hemant	6	Raw – 12 Hr	7.167	7.217	-0.050	0.055	0.022	-2.236	0.076
	6	Raw – 24 Hr	7.167	7.267	-0.100	0.063	0.026	-3.873	0.012
	6	Raw – 48 Hr	7.167	7.333	-0.167	0.082	0.033	-5.000	0.004
Shishir	6	Raw – 12 Hr	7.183	7.267	-0.083	0.041	0.017	-5.000	0.004
	6	Raw – 24 Hr	7.183	7.333	-0.150	0.055	0.022	-6.708	0.001
	6	Raw – 48 Hr	7.183	7.383	-0.200	0.063	0.026	-7.746	0.001

Source - Tube well Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	7.233	7.300	-0.067	0.052	0.021	-3.162	0.025
	6	Raw – 24 Hr	7.233	7.383	-0.150	0.055	0.022	-6.708	0.001
	6	Raw – 48 Hr	7.233	7.467	-0.233	0.052	0.021	-	<
Greeshma	6	Raw – 12 Hr	7.483	7.550	-0.067	0.052	0.021	-3.162	0.025
	6	Raw – 24 Hr	7.483	7.650	-0.167	0.052	0.021	-7.906	0.001
	6	Raw – 48 Hr	7.483	7.717	-0.233	0.082	0.033	-7.000	0.001
Varsha	6	Raw – 12 Hr	6.967	7.000	-0.033	0.052	0.021	-1.581	0.175
	6	Raw – 24 Hr	6.967	7.100	-0.133	0.103	0.042	-3.162	0.025
	6	Raw – 48 Hr	6.967	7.167	-0.200	0.089	0.037	-5.477	0.003
Sharad	6	Raw – 12 Hr	7.033	7.050	-0.017	0.041	0.017	-1.000	0.363
	6	Raw – 24 Hr	7.033	7.050	-0.017	0.041	0.017	-1.000	0.363
	6	Raw – 48 Hr	7.033	7.083	-0.050	0.055	0.022	-2.236	0.076
Hemant	6	Raw – 12 Hr	7.167	7.200	-0.033	0.052	0.021	-1.581	0.175
	6	Raw – 24 Hr	7.167	7.233	-0.067	0.052	0.021	-3.162	0.025
	6	Raw – 48 Hr	7.167	7.317	-0.150	0.084	0.034	-4.392	0.007
Shishir	6	Raw – 12 Hr	7.183	7.250	-0.067	0.052	0.021	-3.162	0.025
	6	Raw – 24 Hr	7.183	7.300	-0.117	0.041	0.017	-7.000	0.001
	6	Raw – 48 Hr	7.183	7.333	-0.150	0.055	0.022	-6.708	0.001

a) Source –River Vessel – *Tamra*

For River samples, there was increase in pH of water stored in *Tamra* vessel for *rutu* – *Greeshma, Varsha, Sharad, Hemant* and *Shishir* for all the time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). For *Vasant rutu*, the increase was insignificant during time interval Raw – 12 Hr (p-value = 0.175) but subsequent intervals showed significant increase (P-values = 0.007 & 0.001 respectively).

Source River Vessel - Stainless steel

For River samples, there was increase in pH of water stored in stainless steel vessel for *rutu* – *Varsha, Hemant* and *Shishir* for all the time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). For *Vasant, Greeshma* and *Sharad rutu*, the increase was insignificant during time interval Raw – 12 Hr (p-values > 0.05) but subsequent time intervals showed significant increase (P-values < 0.05).

b) Source – Tube well Vessel– *Tamra*

For tube well samples, there was increase in pH of water stored in *Tamra* vessel for *rutu* – *Vasant, Greeshma, Varsha* and *Shishir* for all the time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). For *Sharad rutu*, there was no significant increase in pH is observed (all p-values > 0.05). For *Hemant rutu*, the increase was insignificant during time interval Raw – 12 Hr (p-value = 0.076) but subsequent intervals showed significant increase (P-values = 0.012 & 0.004 respectively).

Source - Tube well Vessel - Stainless steel

For tube well samples, there was increase in pH of water stored in stainless steel vessel for *rutu Vasant, Greeshma, Varsha* and *Shishir* for all the time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). For *Hemant rutu*, the increase was insignificant during time interval Raw – 12 Hr (p-values > 0.05) but subsequent intervals showed significant increase (P-values < 0.05). For *Sharad rutu*, there was no significant increase observed for any of the time interval Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values > 0.05)

v) Total Suspended Solids (TSS)

d) Source –River Vessel – *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	9.117	9.033	0.083	0.075	0.031	2.712	0.042
	6	Raw – 24 Hr	9.117	8.933	0.183	0.117	0.048	3.841	0.012
	6	Raw – 48 Hr	9.117	8.817	0.300	0.110	0.045	6.708	0.001
Greeshma	6	Raw – 12 Hr	9.117	9.000	0.117	0.041	0.017	7.000	0.001
	6	Raw – 24 Hr	9.117	8.950	0.167	0.082	0.033	5.000	0.004
	6	Raw – 48 Hr	9.117	8.850	0.267	0.151	0.061	4.339	0.007
Varsha	6	Raw – 12 Hr	11.833	11.750	0.083	0.041	0.017	5.000	0.004
	6	Raw – 24 Hr	11.833	11.700	0.133	0.052	0.021	6.325	0.001
	6	Raw – 48 Hr	11.833	11.633	0.200	0.063	0.026	7.746	0.001
Sharad	6	Raw – 12 Hr	9.017	8.883	0.133	0.103	0.042	3.162	0.025
	6	Raw – 24 Hr	9.017	8.750	0.267	0.082	0.033	8.000	< 0.001
	6	Raw – 48 Hr	9.017	8.683	0.333	0.082	0.033	10.000	< 0.001
Hemant	6	Raw – 12 Hr	9.783	9.700	0.083	0.041	0.017	5.000	0.004
	6	Raw – 24 Hr	9.783	9.617	0.167	0.082	0.033	5.000	0.004
	6	Raw – 48 Hr	9.783	9.550	0.233	0.052	0.021	11.068	< 0.001
Shishir	6	Raw – 12 Hr	9.700	9.600	0.100	0.000	0.000	33776	< 0.001
	6	Raw – 24 Hr	9.700	9.567	0.133	0.052	0.021	6.325	0.001
	6	Raw – 48 Hr	9.700	9.467	0.233	0.052	0.021	11.068	< 0.001

Source - River Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	9.117	9.033	0.083	0.041	0.017	5.000	0.004
	6	Raw – 24 Hr	9.117	8.933	0.183	0.098	0.040	4.568	0.006
	6	Raw – 48 Hr	9.117	8.833	0.283	0.117	0.048	5.937	0.002
Greeshma	6	Raw – 12 Hr	9.117	9.017	0.100	0.000	0.000	-	-
	6	Raw – 24 Hr	9.117	8.950	0.167	0.082	0.033	5.000	0.004
	6	Raw – 48 Hr	9.117	8.833	0.283	0.117	0.048	5.937	0.002
Varsha	6	Raw – 12 Hr	11.833	11.767	0.067	0.052	0.021	3.162	0.025
	6	Raw – 24 Hr	11.833	11.700	0.133	0.052	0.021	6.325	0.001
	6	Raw – 48 Hr	11.833	11.650	0.183	0.075	0.031	5.966	0.002
Sharad	6	Raw – 12 Hr	9.000	8.900	0.100	0.110	0.045	2.236	0.076
	6	Raw – 24 Hr	9.000	8.767	0.233	0.103	0.042	5.534	0.003
	6	Raw – 48 Hr	9.000	8.700	0.300	0.089	0.037	8.216	< 0.001
Hemant	6	Raw – 12 Hr	9.783	9.700	0.083	0.041	0.017	5.000	0.004
	6	Raw – 24 Hr	9.783	9.633	0.150	0.084	0.034	4.392	0.007
	6	Raw – 48 Hr	9.783	9.550	0.233	0.052	0.021	11.068	< 0.001
Shishir	6	Raw – 12 Hr	9.700	9.617	0.083	0.041	0.017	5.000	0.004
	6	Raw – 24 Hr	9.700	9.567	0.133	0.052	0.021	6.325	0.001
	6	Raw – 48 Hr	9.700	9.483	0.217	0.041	0.017	13.000	< 0.001

b) Source-Tube well Vessel - *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	6.883	6.850	0.033	0.082	0.033	1.000	0.363
	6	Raw – 24 Hr	6.883	6.767	0.117	0.075	0.031	3.796	0.013
	6	Raw – 48 Hr	6.883	6.800	0.083	0.075	0.031	2.712	0.042
Greeshma	6	Raw – 12 Hr	6.200	5.983	0.217	0.075	0.031	7.050	0.001
	6	Raw – 24 Hr	6.200	5.850	0.350	0.084	0.034	10.247	< 0.001
	6	Raw – 48 Hr	6.200	5.800	0.400	0.089	0.037	10.954	< 0.001
Varsha	6	Raw – 12 Hr	7.783	7.517	0.267	0.052	0.021	12.649	< 0.001
	6	Raw – 24 Hr	7.783	7.500	0.283	0.160	0.065	4.332	0.007
	6	Raw – 48 Hr	7.783	7.467	0.317	0.147	0.060	5.270	0.003
Sharad	6	Raw – 12 Hr	5.983	5.883	0.100	0.000	0.000	5340	< 0.001
	6	Raw – 24 Hr	5.983	5.850	0.133	0.082	0.033	4.000	0.010
	6	Raw – 48 Hr	5.983	5.767	0.217	0.098	0.040	5.398	0.003
Hemant	6	Raw – 12 Hr	7.100	6.983	0.117	0.041	0.017	7.000	0.001
	6	Raw – 24 Hr	7.100	6.800	0.300	0.063	0.026	11.619	< 0.001
	6	Raw – 48 Hr	7.100	6.717	0.383	0.075	0.031	12.474	< 0.001
Shishir	6	Raw – 12 Hr	6.783	6.650	0.133	0.052	0.021	6.325	0.001
	6	Raw – 24 Hr	6.783	6.450	0.333	0.082	0.033	10.000	< 0.001
	6	Raw – 48 Hr	6.783	6.333	0.450	0.055	0.022	20.125	< 0.001

Source Tube well Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	6.883	6.867	0.017	0.075	0.031	0.542	0.611
	6	Raw – 24 Hr	6.883	6.767	0.117	0.075	0.031	3.796	0.013
	6	Raw – 48 Hr	6.883	6.800	0.083	0.075	0.031	2.712	0.042
Greeshma	6	Raw – 12 Hr	6.200	5.983	0.217	0.075	0.031	7.050	0.001
	6	Raw – 24 Hr	6.200	5.867	0.333	0.082	0.033	10.000	< 0.001
	6	Raw – 48 Hr	6.200	5.817	0.383	0.075	0.031	12.474	< 0.001
Varsha	6	Raw – 12 Hr	7.783	7.500	0.283	0.075	0.031	9.220	< 0.001
	6	Raw – 24 Hr	7.783	7.517	0.267	0.175	0.071	3.730	0.014
	6	Raw – 48 Hr	7.783	7.450	0.333	0.137	0.056	5.976	0.002
Sharad	6	Raw – 12 Hr	5.983	5.900	0.083	0.041	0.017	5.000	0.004
	6	Raw – 24 Hr	5.983	5.850	0.133	0.082	0.033	4.000	0.010
	6	Raw – 48 Hr	5.983	5.767	0.217	0.098	0.040	5.398	0.003
Hemant	6	Raw – 12 Hr	7.100	7.000	0.100	0.063	0.026	3.873	0.012
	6	Raw – 24 Hr	7.100	6.800	0.300	0.063	0.026	11.619	< 0.001
	6	Raw – 48 Hr	7.100	6.700	0.400	0.063	0.026	15.492	< 0.001
Shishir	6	Raw – 12 Hr	6.783	6.633	0.150	0.055	0.022	6.708	0.001
	6	Raw – 24 Hr	6.783	6.467	0.317	0.041	0.017	19.000	< 0.001
	6	Raw – 48 Hr	6.783	6.350	0.433	0.082	0.033	13.000	< 0.001

a) Source –River Vessel – *Tamra*

For River samples, at every *rutu* of – *Vasant, Greeshma, Varsha, Sharad, Hemant and Shishir,* water stored in *Tamra* vessel showed significant reduction in TSS at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

Source - River Vessel - Stainless steel

Also, water stored in Stainless steel vessel showed significant reduction in TSS at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05) for all the *rutus* other than *Sharad*. And *in Sharad rutu,* reduction for time interval Raw – 12 was insignificant (P-value = 0.076) while subsequent time intervals showed significant reduction in TSS (P-values < 0.05).

b) Source-Tube well Vessel - *Tamra*

For Tube well samples, for *rutu – Greeshma, Varsha, Sharad, Hemant* and *Shishir,* water stored in *Tamra* vessel showed significant reduction in TSS at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05) while for *Vasant rutu,* reduction in TSS was insignificant for time interval Raw – 12 Hr (P-value = 0.363) while for subsequent time intervals the reduction was significant (both P-values < 0.05).

Source Tube well Vessel - Stainless steel

Also, water stored in Stainless steel vessel showed significant reduction in TSS for *Greeshma, Varsha, Sharad, Hemant* and *Shishir rutu* at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05) but for *Vasant rutu,* the reduction in TSS for time interval Raw – 12 Hr was insignificant (P-value = 0.611) at 5% level of significance while other time intervals Raw – 24 hr and Raw – 48 Hr shows significant reduction in TSS (P-values = 0.013 & 0.042 respectively).

vi)Total Dissolved Solids (TDS)

a) Source –River Vessel - *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	222.000	202.000	20.000	1.414	0.577	34.641	< 0.001
	6	Raw – 24 Hr	222.000	188.833	33.167	2.317	0.946	35.069	< 0.001
	6	Raw – 48 Hr	222.000	175.833	46.167	1.169	0.477	96.733	< 0.001
Greeshma	6	Raw – 12 Hr	221.500	204.333	17.167	1.941	0.792	21.666	< 0.001
	6	Raw – 24 Hr	221.500	183.000	38.500	4.764	1.945	19.794	< 0.001
	6	Raw – 48 Hr	221.500	173.333	48.167	1.941	0.792	60.792	< 0.001
Varsha	6	Raw – 12 Hr	279.833	258.000	21.833	1.602	0.654	33.382	< 0.001
	6	Raw – 24 Hr	279.833	241.167	38.667	4.320	1.764	21.922	< 0.001
	6	Raw – 48 Hr	279.833	232.333	47.500	1.761	0.719	66.083	< 0.001
Sharad	6	Raw – 12 Hr	219.833	202.167	17.667	4.131	1.687	10.475	< 0.001
	6	Raw – 24 Hr	219.833	184.000	35.833	5.913	2.414	14.843	< 0.001
	6	Raw – 48 Hr	219.833	167.667	52.167	2.229	0.910	57.337	< 0.001
Hemant	6	Raw – 12 Hr	234.000	219.333	14.667	2.875	1.174	12.495	< 0.001
	6	Raw – 24 Hr	234.000	202.667	31.333	1.366	0.558	56.176	< 0.001
	6	Raw – 48 Hr	234.000	191.000	43.000	1.789	0.730	58.880	< 0.001
Shishir	6	Raw – 12 Hr	223.167	207.500	15.667	4.367	1.783	8.789	< 0.001
	6	Raw – 24 Hr	223.167	191.667	31.500	4.087	1.668	18.881	< 0.001
	6	Raw – 48 Hr	223.167	173.333	49.833	1.169	0.477	104.415	< 0.001

Source - River Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	222.000	218.333	3.667	1.033	0.422	8.696	0.001
	6	Raw – 24 Hr	222.000	214.667	7.333	0.816	0.333	22.000	< 0.001
	6	Raw – 48 Hr	222.000	213.167	8.833	5.913	2.414	3.659	< 0.001
Greeshma	6	Raw – 12 Hr	221.500	220.167	1.333	0.516	0.211	6.325	0.022
	6	Raw – 24 Hr	221.500	218.833	2.667	0.516	0.211	12.649	0.001
	6	Raw – 48 Hr	221.500	218.000	3.500	0.548	0.224	15.652	0.001
Varsha	6	Raw – 12 Hr	279.833	274.833	5.000	3.742	1.528	3.273	< 0.001
	6	Raw – 24 Hr	279.833	269.333	10.500	3.782	1.544	6.801	< 0.001
	6	Raw – 48 Hr	279.833	266.500	13.333	4.412	1.801	7.402	< 0.001
Sharad	6	Raw – 12 Hr	219.833	216.833	3.000	0.894	0.365	8.216	0.001
	6	Raw – 24 Hr	219.833	213.167	6.667	1.506	0.615	10.847	< 0.001
	6	Raw – 48 Hr	219.833	210.000	9.833	0.753	0.307	31.997	< 0.001
Hemant	6	Raw – 12 Hr	234.000	230.167	3.833	1.472	0.601	6.379	0.001
	6	Raw – 24 Hr	234.000	226.833	7.167	1.722	0.703	10.192	< 0.001
	6	Raw – 48 Hr	234.000	222.833	11.167	1.722	0.703	15.881	< 0.001
Shishir	6	Raw – 12 Hr	223.167	219.833	3.333	1.211	0.494	6.742	0.001
	6	Raw – 24 Hr	223.167	216.333	6.833	1.472	0.601	11.371	< 0.001
	6	Raw – 48 Hr	223.167	212.500	10.667	1.033	0.422	25.298	< 0.001

b) Source-Tube well Vessel - *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	366.833	350.500	16.333	1.506	0.615	26.574	< 0.001
	6	Raw – 24 Hr	366.833	333.833	33.000	3.033	1.238	26.650	< 0.001
	6	Raw – 48 Hr	366.833	322.000	44.833	2.858	1.167	38.429	< 0.001
Greeshma	6	Raw – 12 Hr	344.000	327.000	17.000	2.966	1.211	14.037	< 0.001
	6	Raw – 24 Hr	344.000	303.833	40.167	2.858	1.167	34.429	< 0.001
	6	Raw – 48 Hr	344.000	294.167	49.833	2.787	1.138	43.800	< 0.001
Varsha	6	Raw – 12 Hr	397.833	383.000	14.833	0.753	0.307	48.267	< 0.001
	6	Raw – 24 Hr	397.833	378.000	19.833	0.753	0.307	64.537	< 0.001
	6	Raw – 48 Hr	397.833	376.167	21.667	1.033	0.422	51.387	< 0.001
Sharad	6	Raw – 12 Hr	326.833	304.833	22.000	2.966	1.211	18.166	< 0.001
	6	Raw – 24 Hr	326.833	282.333	44.500	3.619	1.478	30.116	< 0.001
	6	Raw – 48 Hr	326.833	276.667	50.167	2.994	1.222	41.037	< 0.001
Hemant	6	Raw – 12 Hr	335.500	323.167	12.333	1.366	0.558	22.112	< 0.001
	6	Raw – 24 Hr	335.500	306.667	28.833	4.535	1.851	15.574	< 0.001
	6	Raw – 48 Hr	335.500	292.167	43.333	1.966	0.803	53.980	< 0.001
Shishir	6	Raw – 12 Hr	333.833	316.833	17.000	7.537	3.077	5.525	0.001
	6	Raw – 24 Hr	333.833	301.333	32.500	1.643	0.671	48.448	< 0.001
	6	Raw – 48 Hr	333.833	290.667	43.167	2.317	0.946	45.643	< 0.001

Source-Tube well Vessel Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	366.833	365.000	1.833	0.408	0.167	11.000	< 0.001
	6	Raw – 24 Hr	366.833	359.167	7.667	1.033	0.422	18.183	< 0.001
	6	Raw – 48 Hr	366.833	355.833	11.000	1.414	0.577	19.053	< 0.001
Greeshma	6	Raw – 12 Hr	344.000	339.833	4.167	0.983	0.401	10.381	< 0.001
	6	Raw – 24 Hr	344.000	336.000	8.000	2.098	0.856	9.342	< 0.001
	6	Raw – 48 Hr	344.000	333.167	10.833	2.483	1.014	10.686	< 0.001
Varsha	6	Raw – 12 Hr	397.833	394.000	3.833	0.983	0.401	9.550	< 0.001
	6	Raw – 24 Hr	397.833	390.667	7.167	1.722	0.703	10.192	< 0.001
	6	Raw – 48 Hr	397.833	387.333	10.500	1.871	0.764	13.748	< 0.001
Sharad	6	Raw – 12 Hr	326.833	322.333	4.500	0.837	0.342	13.175	< 0.001
	6	Raw – 24 Hr	326.833	318.167	8.667	1.211	0.494	17.529	< 0.001
	6	Raw – 48 Hr	326.833	313.000	13.833	2.229	0.910	15.204	< 0.001
Hemant	6	Raw – 12 Hr	335.500	332.500	3.000	0.894	0.365	8.216	< 0.001
	6	Raw – 24 Hr	335.500	329.333	6.167	1.472	0.601	10.262	< 0.001
	6	Raw – 48 Hr	335.500	327.000	8.500	1.378	0.563	15.105	< 0.001
Shishir	6	Raw – 12 Hr	333.833	329.667	4.167	0.753	0.307	13.558	< 0.001
	6	Raw – 24 Hr	333.833	327.500	6.333	1.633	0.667	9.500	< 0.001
	6	Raw – 48 Hr	333.833	324.833	9.000	1.897	0.775	11.619	< 0.001

a) Source –River Vessel - *Tamra*

For River samples, at every *rutu* of – *Vasant, Greeshma, Varsha, Sharad, Hemant and Shishir* water stored in *Tamra* vessel showed significant reduction in TDS at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

Source - River Vessel - Stainless steel

Also, water stored in Stainless steel vessel showed significant reduction in TDS for all *rutu* at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

b) Source-Tube well Vessel - *Tamra*

For Tube well samples, at every *rutu* of – *Vasant, Greeshma, Varsha, Sharad, Hemant* and *Shishir* water stored in *Tamra* vessel showed significant reduction in TDS at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

Source-Tube well Vessel Stainless steel

Also, water stored in Stainless steel vessel showed significant reduction in TDS for all *rutu* at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

vii) Most Probable Number (MPN)

a) Source –River Vessel– *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	408.833	22.500	386.333	10.013	4.088	94.506	< 0.001
	6	Raw – 24 Hr	408.833	14.667	394.167	10.028	4.094	96.278	< 0.001
	6	Raw – 48 Hr	408.833	9.167	399.667	11.378	4.645	86.039	< 0.001
Greeshma	6	Raw – 12 Hr	449.833	27.167	422.667	12.533	5.116	82.610	< 0.001
	6	Raw – 24 Hr	449.833	18.167	431.667	17.143	6.998	61.681	< 0.001
	6	Raw – 48 Hr	449.833	6.667	443.167	17.589	7.181	61.717	< 0.001
Varsha	6	Raw – 12 Hr	583.833	38.667	545.167	20.282	8.280	65.840	< 0.001
	6	Raw – 24 Hr	583.833	23.833	560.000	18.330	7.483	74.833	< 0.001
	6	Raw – 48 Hr	583.833	8.500	575.333	18.305	7.473	76.989	< 0.001
Sharad	6	Raw – 12 Hr	219.000	14.167	204.833	4.916	2.007	102.063	< 0.001
	6	Raw – 24 Hr	219.000	9.833	209.167	4.956	2.023	103.370	< 0.001
	6	Raw – 48 Hr	219.000	7.333	211.667	5.086	2.076	101.943	< 0.001
Hemant	6	Raw – 12 Hr	395.000	20.000	375.000	2.098	0.856	437.906	< 0.001
	6	Raw – 24 Hr	395.000	14.667	380.333	2.422	0.989	384.631	< 0.001
	6	Raw – 48 Hr	395.000	8.167	386.833	2.639	1.078	358.994	< 0.001
Shishir	6	Raw – 12 Hr	392.167	18.500	373.667	0.516	0.211	1772.457	< 0.001
	6	Raw – 24 Hr	392.167	12.667	379.500	0.548	0.224	1697.176	< 0.001
	6	Raw – 48 Hr	392.167	8.833	383.333	1.633	0.667	575.000	< 0.001

Source River Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	408.833	380.667	28.167	8.085	3.301	8.534	< 0.001
	6	Raw – 24 Hr	408.833	358.500	50.333	5.680	2.319	21.705	< 0.001
	6	Raw – 48 Hr	408.833	355.000	53.833	5.981	2.442	22.049	< 0.001
Greeshma	6	Raw – 12 Hr	449.833	429.333	20.500	8.597	3.510	5.841	0.001
	6	Raw – 24 Hr	449.833	408.667	41.167	10.381	4.238	9.714	< 0.001
	6	Raw – 48 Hr	449.833	399.667	50.167	2.229	0.910	55.139	< 0.001
Varsha	6	Raw – 12 Hr	583.833	555.833	28.000	4.561	1.862	15.038	< 0.001
	6	Raw – 24 Hr	583.833	520.500	63.333	3.327	1.358	46.634	< 0.001
	6	Raw – 48 Hr	583.833	515.500	68.333	2.805	1.145	59.678	< 0.001
Sharad	6	Raw – 12 Hr	219.000	205.833	13.167	3.971	1.621	8.122	< 0.001
	6	Raw – 24 Hr	219.000	196.500	22.500	2.811	1.147	19.609	< 0.001
	6	Raw – 48 Hr	219.000	189.833	29.167	4.446	1.815	16.069	< 0.001
Hemant	6	Raw – 12 Hr	395.000	378.167	16.833	4.665	1.905	8.838	< 0.001
	6	Raw – 24 Hr	395.000	360.333	34.667	5.465	2.231	15.538	< 0.001
	6	Raw – 48 Hr	395.000	353.833	41.167	6.047	2.469	16.675	< 0.001
Shishir	6	Raw – 12 Hr	392.167	379.333	12.833	2.483	1.014	12.659	< 0.001
	6	Raw – 24 Hr	392.167	361.833	30.333	0.816	0.333	91.000	< 0.001
	6	Raw – 48 Hr	392.167	353.333	38.833	2.401	0.980	39.611	< 0.001

b) Source-Tube well Vessel – *Tamra*

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	388.000	24.000	364.000	3.225	1.317	276.478	< 0.001
	6	Raw – 24 Hr	388.000	15.333	372.667	3.615	1.476	252.530	< 0.001
	6	Raw – 48 Hr	388.000	7.833	380.167	3.488	1.424	266.971	< 0.001
Greeshma	6	Raw – 12 Hr	413.167	24.833	388.333	3.141	1.282	302.827	< 0.001
	6	Raw – 24 Hr	413.167	14.333	398.833	1.941	0.792	503.371	< 0.001
	6	Raw – 48 Hr	413.167	6.833	406.333	3.204	1.308	310.630	< 0.001
Varsha	6	Raw – 12 Hr	492.833	30.333	462.500	6.025	2.460	188.033	< 0.001
	6	Raw – 24 Hr	492.833	18.833	474.000	5.292	2.160	219.419	< 0.001
	6	Raw – 48 Hr	492.833	8.333	484.500	7.007	2.861	169.367	< 0.001
Sharad	6	Raw – 12 Hr	210.000	17.333	192.667	1.862	0.760	253.470	< 0.001
	6	Raw – 24 Hr	210.000	8.167	201.833	3.371	1.376	146.640	< 0.001
	6	Raw – 48 Hr	210.000	4.333	205.667	4.367	1.783	115.372	< 0.001
Hemant	6	Raw – 12 Hr	394.000	24.167	369.833	3.430	1.400	264.092	< 0.001
	6	Raw – 24 Hr	394.000	16.000	378.000	3.162	1.291	292.798	< 0.001
	6	Raw – 48 Hr	394.000	8.000	386.000	3.286	1.342	287.707	< 0.001
Shishir	6	Raw – 12 Hr	388.833	24.167	364.667	3.777	1.542	236.489	< 0.001
	6	Raw – 24 Hr	388.833	14.167	374.667	2.422	0.989	378.900	< 0.001
	6	Raw – 48 Hr	388.833	7.333	381.500	2.881	1.176	324.363	< 0.001

Source Tube well Vessel - Stainless steel

Rutu	N	Comparison	Mean score			S.D ±	S.E.	Paired 't'	P
			Bef	Aft	diff				
Vasant	6	Raw – 12 Hr	388.000	372.167	15.833	8.085	3.301	4.797	0.005
	6	Raw – 24 Hr	388.000	348.500	39.500	3.886	1.586	24.899	< 0.001
	6	Raw – 48 Hr	388.000	338.000	50.000	4.690	1.915	26.112	< 0.001
Greeshma	6	Raw – 12 Hr	413.167	385.000	28.167	1.169	0.477	59.017	< 0.001
	6	Raw – 24 Hr	413.167	360.667	52.500	2.429	0.992	52.943	< 0.001
	6	Raw – 48 Hr	413.167	351.333	61.833	2.041	0.833	74.200	< 0.001
Varsha	6	Raw – 12 Hr	492.833	469.667	23.167	1.835	0.749	30.927	< 0.001
	6	Raw – 24 Hr	492.833	443.333	49.500	4.231	1.727	28.659	< 0.001
	6	Raw – 48 Hr	492.833	435.667	57.167	5.115	2.088	27.374	< 0.001
Sharad	6	Raw – 12 Hr	210.000	196.333	13.667	5.538	2.261	6.045	0.002
	6	Raw – 24 Hr	210.000	187.333	22.667	3.141	1.282	17.676	< 0.001
	6	Raw – 48 Hr	210.000	177.500	32.500	4.506	1.839	17.669	< 0.001
Hemant	6	Raw – 12 Hr	394.000	374.333	19.667	4.803	1.961	10.030	< 0.001
	6	Raw – 24 Hr	394.000	350.833	43.167	3.971	1.621	26.629	< 0.001
	6	Raw – 48 Hr	394.000	339.167	54.833	4.355	1.778	30.841	< 0.001
Shishir	6	Raw – 12 Hr	388.833	367.500	21.333	10.132	4.137	5.157	0.004
	6	Raw – 24 Hr	388.833	348.833	40.000	3.225	1.317	30.382	< 0.001
	6	Raw – 48 Hr	388.833	339.000	49.833	4.446	1.815	27.455	< 0.001

a) Source –River Vessel– *Tamra*

For River samples, at every *rutu* of – *Vasant, Greeshma, Varsha, Sharad, Hemant* and *Shishir* water stored in *Tamra* vessel showed significant reduction in MPN at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

Source River Vessel - Stainless steel

Also, water stored in Stainless steel vessel showed significant reduction in MPN for all *rutu* at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

b) Source-Tube well Vessel – *Tamra*

For Tube well samples, at every *rutu* of – *Vasant, Greeshma, Varsha, Sharad, Hemant* and *Shishir* water stored in *Tamra* vessel showed significant reduction in MPN at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

Source Tube well Vessel - Stainless steel

Also, water stored in Stainless steel vessel showed significant reduction in MPN for all *rutu* at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).

2) BETWEEN GROUP EFFECT

i) Turbidity

A) Source – River

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	0.117	0.100	0.017	[-0.062 , 0.096]	0.542	0.611
	6	Raw – 24 Hr	0.183	0.167	0.017	[-0.062 , 0.096]	0.542	0.611
	6	Raw – 48 Hr	0.233	0.233	0.000	[-0.066 , 0.066]	0.000	1.000
Greeshma	6	Raw – 12 Hr	0.050	0.067	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 24 Hr	0.183	0.183	0.000	[-0.066 , 0.066]	0.000	1.000
	6	Raw – 48 Hr	0.367	0.367	0.000	[-0.066 , 0.066]	0.000	1.000
Varsha	6	Raw – 12 Hr	0.183	0.167	0.017	[-0.062 , 0.096]	0.542	0.611
	6	Raw – 24 Hr	0.367	0.367	0.000	[-0.066 , 0.066]	0.000	1.000
	6	Raw – 48 Hr	0.550	0.533	0.017	[-0.123 , 0.156]	0.307	0.771
Sharad	6	Raw – 12 Hr	0.033	0.033	0.000	[-0.066 , 0.066]	0.000	1.000
	6	Raw – 24 Hr	0.067	0.033	0.033	[-0.021 , 0.088]	1.581	0.175
	6	Raw – 48 Hr	0.133	0.117	0.017	[-0.026 , 0.06]	1.000	0.363
Hemant	6	Raw – 12 Hr	0.200	0.183	0.017	[-0.087 , 0.12]	0.415	0.695
	6	Raw – 24 Hr	0.350	0.350	0.000	[-0.066 , 0.066]	0.000	1.000
	6	Raw – 48 Hr	0.417	0.383	0.033	[-0.021 , 0.088]	1.581	0.175
Shishir	6	Raw – 12 Hr	0.333	0.350	-0.017	[-0.12 , 0.087]	-0.415	0.695
	6	Raw – 24 Hr	0.433	0.417	0.017	[-0.138 , 0.171]	0.277	0.793
	6	Raw – 48 Hr	0.500	0.483	0.017	[-0.123 , 0.156]	0.307	0.771

B) Source –Tube well

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	0.100	0.083	0.017	[-0.062 , 0.096]	0.542	0.611
	6	Raw – 24 Hr	0.133	0.133	0.000	[-0.094 , 0.094]	0.000	1.000
	6	Raw – 48 Hr	0.183	0.167	0.017	[-0.087 , 0.12]	0.415	0.695
Greeshma	6	Raw – 12 Hr	0.050	0.050	0.000	-	-	-
	6	Raw – 24 Hr	0.117	0.100	0.017	[-0.026 , 0.06]	1.000	0.363
	6	Raw – 48 Hr	0.117	0.117	0.000	-	-	-
Varsha	6	Raw – 12 Hr	0.033	0.017	0.017	[-0.026 , 0.06]	1.000	0.363
	6	Raw – 24 Hr	0.033	0.017	0.017	[-0.026 , 0.06]	1.000	0.363
	6	Raw – 48 Hr	0.067	0.067	0.000	[-0.066 , 0.066]	0.000	1.000
Sharad	6	Raw – 12 Hr	0.133	0.117	0.017	[-0.062 , 0.096]	0.542	0.611
	6	Raw – 24 Hr	0.183	0.183	0.000	[-0.066 , 0.066]	0.000	1.000
	6	Raw – 48 Hr	0.217	0.217	0.000	[-0.066 , 0.066]	0.000	1.000
Hemant	6	Raw – 12 Hr	0.100	0.100	0.000	-	-	-
	6	Raw – 24 Hr	0.250	0.233	0.017	[-0.026 , 0.06]	1.000	0.363
	6	Raw – 48 Hr	0.333	0.317	0.017	[-0.026 , 0.06]	1.000	0.363
Shishir	6	Raw – 12 Hr	0.067	0.067	0.000	-	-	-
	6	Raw – 24 Hr	0.133	0.117	0.017	[-0.106 , 0.139]	0.349	0.741
	6	Raw – 48 Hr	0.233	0.233	0.000	[-0.094 , 0.094]	0.000	1.000

A) Source – River

For river as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir* reduction in turbidity for water stored in *Tamra* vessel and Stainless steel vessel was not significantly different (all P-value> 0.05) i.e. equal.

B) Source –Tube well

Also, for tube well as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir* reduction in turbidity for water stored in *Tamra* vessel and Stainless steel vessel was not significantly different (all P-value> 0.05) i.e. equal.

ii) Temperature

A) Source –River

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	1.500	1.167	0.333	[-0.524 , 1.19]	1.000	0.363
	6	Raw – 24 Hr	-0.167	-0.500	0.333	[-0.209 , 0.875]	1.581	0.175
	6	Raw – 48 Hr	-1.167	-1.167	0.000	[-0.664 , 0.664]	0.000	1.000
Greeshma	6	Raw – 12 Hr	0.333	0.333	0.000	-	-	-
	6	Raw – 24 Hr	0.167	0.000	0.167	[-0.262 , 0.595]	1.000	0.363
	6	Raw – 48 Hr	-0.167	-0.333	0.167	[-0.262 , 0.595]	1.000	0.363
Varsha	6	Raw – 12 Hr	1.000	0.500	0.500	[-0.075 , 1.075]	2.236	0.076
	6	Raw – 24 Hr	1.333	1.167	0.167	[-0.262 , 0.595]	1.000	0.363
	6	Raw – 48 Hr	2.000	1.667	0.333	[-0.524 , 1.19]	1.000	0.363
Sharad	6	Raw – 12 Hr	1.000	0.500	0.500	[-0.075 , 1.075]	2.236	0.076
	6	Raw – 24 Hr	0.167	-0.167	0.333	[-0.209 , 0.875]	1.581	0.175
	6	Raw – 48 Hr	-0.500	-1.000	0.500	[-0.378 , 1.378]	1.464	0.203
Hemant	6	Raw – 12 Hr	0.667	0.667	0.000	-	-	-
	6	Raw – 24 Hr	1.000	0.833	0.167	[-0.262 , 0.595]	1.000	0.363
	6	Raw – 48 Hr	1.500	1.333	0.167	[-0.262 , 0.595]	1.000	0.363
Shishir	6	Raw – 12 Hr	0.333	0.333	0.000	[-0.664 , 0.664]	0.000	1.000
	6	Raw – 24 Hr	0.500	0.500	0.000	[-0.664 , 0.664]	0.000	1.000
	6	Raw – 48 Hr	1.333	1.167	0.167	[-0.623 , 0.957]	0.542	0.611

B) Source –Tube well

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	1.167	1.000	0.167	[-0.262 , 0.595]	1.000	0.363
	6	Raw – 24 Hr	-0.167	-	0.167	[-0.623 , 0.957]	0.542	0.611
	6	Raw – 48 Hr	-1.167	-	0.333	[-0.209 , 0.875]	1.581	0.175
Greeshma	6	Raw – 12 Hr	0.500	0.333	0.167	[-0.623 , 0.957]	0.542	0.611
	6	Raw – 24 Hr	0.167	0.167	0.000	-	-	-
	6	Raw – 48 Hr	0.333	0.167	0.167	[-0.865 , 1.198]	0.415	0.695
Varsha	6	Raw – 12 Hr	1.167	1.000	0.167	[-0.262 , 0.595]	1.000	0.363
	6	Raw – 24 Hr	1.500	1.333	0.167	[-0.262 , 0.595]	1.000	0.363
	6	Raw – 48 Hr	2.167	1.833	0.333	[-0.209 , 0.875]	1.581	0.175
Sharad	6	Raw – 12 Hr	1.167	0.833	0.333	[-0.209 , 0.875]	1.581	0.175
	6	Raw – 24 Hr	0.333	0.000	0.333	[-0.209 , 0.875]	1.581	0.175
	6	Raw – 48 Hr	-0.167	-	0.333	[-0.209 , 0.875]	1.581	0.175
Hemant	6	Raw – 12 Hr	0.667	0.500	0.167	[-0.262 , 0.595]	1.000	0.363
	6	Raw – 24 Hr	0.833	0.833	0.000	[-0.664 , 0.664]	0.000	1.000
	6	Raw – 48 Hr	1.167	1.000	0.167	[-0.262 , 0.595]	1.000	0.363
Shishir	6	Raw – 12 Hr	0.667	0.333	0.333	[-0.209 , 0.875]	1.581	0.175
	6	Raw – 24 Hr	0.833	0.500	0.333	[-0.209 , 0.875]	1.581	0.175
	6	Raw – 48 Hr	1.333	1.167	0.167	[-0.262 , 0.595]	1.000	0.363

A) Source –River

For river as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir* changes in temperature for water stored in *Tamra* vessel and Stainless steel vessel was not significantly different (all P-value> 0.05) i.e. equal.

B) Source –Tube well

Also, for tube well as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir* changes in temperature for water stored in *Tamra* vessel and Stainless steel vessel was not significantly different (all P-value> 0.05) i.e. equal.

iii) Hardness

A) Source –River

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	4.500	3.500	1.000	[-0.15 , 2.15]	2.236	0.076
	6	Raw – 24 Hr	8.667	7.333	1.333	[-0.38 , 3.047]	2.000	0.102
	6	Raw – 48 Hr	13.333	8.833	4.500	[2.324 , 6.676]	5.316	0.003
Greeshma	6	Raw – 12 Hr	4.000	2.333	1.667	[0.81 , 2.524]	5.000	0.004
	6	Raw – 24 Hr	7.833	4.000	3.833	[1.797 , 5.87]	4.838	0.005
	6	Raw – 48 Hr	11.167	5.667	5.500	[4.053 , 6.947]	9.774	< 0.001
Varsha	6	Raw – 12 Hr	3.500	3.167	0.333	[-0.209 , 0.875]	1.581	0.175
	6	Raw – 24 Hr	6.500	5.500	1.000	[0.336 , 1.664]	3.873	0.012
	6	Raw – 48 Hr	9.667	6.167	3.500	[2.399 , 4.601]	8.174	< 0.001
Sharad	6	Raw – 12 Hr	3.333	2.167	1.167	[0.377 , 1.957]	3.796	0.013
	6	Raw – 24 Hr	7.667	4.500	3.167	[1.94 , 4.394]	6.635	0.001
	6	Raw – 48 Hr	10.500	5.333	5.167	[3.94 , 6.394]	10.826	< 0.001
Hemant	6	Raw – 12 Hr	3.333	2.333	1.000	[0.336 , 1.664]	3.873	0.012
	6	Raw – 24 Hr	7.167	4.000	3.167	[1.772 , 4.562]	5.836	0.002
	6	Raw – 48 Hr	10.833	5.167	5.667	[3.953 , 7.38]	8.500	< 0.001
Shishir	6	Raw – 12 Hr	3.000	2.000	1.000	[0.336 , 1.664]	3.873	0.012
	6	Raw – 24 Hr	6.000	3.667	2.333	[1.249 , 3.417]	5.534	0.003
	6	Raw – 48 Hr	9.167	5.000	4.167	[2.94 , 5.394]	8.730	< 0.001

B) Source –Tube well

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	2.500	1.000	1.500	[0.925 , 2.075]	6.708	0.001
	6	Raw – 24 Hr	4.333	2.333	2.000	[1.061 , 2.939]	5.477	0.003
	6	Raw – 48 Hr	7.500	4.833	2.667	[1.583 , 3.751]	6.325	0.001
Greeshma	6	Raw – 12 Hr	2.000	1.000	1.000	[0.336 , 1.664]	3.873	0.012
	6	Raw – 24 Hr	4.167	2.667	1.500	[-0.348 , 3.348]	2.087	0.091
	6	Raw – 48 Hr	7.667	4.667	3.000	[2.061 , 3.939]	8.216	< 0.001
Varsha	6	Raw – 12 Hr	2.167	1.167	1.000	[1 , 1]	-	-
	6	Raw – 24 Hr	5.333	3.333	2.000	[1.336 , 2.664]	7.746	0.001
	6	Raw – 48 Hr	7.833	5.833	2.000	[1.061 , 2.939]	5.477	0.003
Sharad	6	Raw – 12 Hr	3.167	1.167	2.000	[1.061 , 2.939]	5.477	0.003
	6	Raw – 24 Hr	5.500	3.500	2.000	[0.516 , 3.484]	3.464	0.018
	6	Raw – 48 Hr	7.833	5.333	2.500	[1.399 , 3.601]	5.839	0.002
Hemant	6	Raw – 12 Hr	2.667	1.500	1.167	[0.377 , 1.957]	3.796	0.013
	6	Raw – 24 Hr	5.500	3.333	2.167	[1.377 , 2.957]	7.050	0.001
	6	Raw – 48 Hr	8.167	5.667	2.500	[1.399 , 3.601]	5.839	0.002
Shishir	6	Raw – 12 Hr	2.500	1.500	1.000	[0.336 , 1.664]	3.873	0.012
	6	Raw – 24 Hr	5.000	3.000	2.000	[0.673 , 3.327]	3.873	0.012
	6	Raw – 48 Hr	7.333	5.000	2.333	[0.166 , 4.501]	2.767	0.040

A) Source –River

For river as source, P-values of paired t tests suggested that, at each of the *rutu* – *Greeshma, Sharad, Hemant, Shishir, Tamra* vessel showed significantly higher reduction in hardness than stainless steel vessel at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-value < 0.05). For *Vasant rutu,* reduction in hardness for water stored in both vessels was insignificant at time intervals Raw – 12 Hr and Raw 24 Hr (P-values = 0.076 & 0.102 respectively) while for time interval Raw – 48 Hr, hardness reduced significantly for water in *Tamra* vessel(P-value = 0.003). For *Varsha Rutu,* reduction in hardness for two vessels was insignificant during time interval Raw – 12 Hr (P-value = 0.175) but for time intervals Raw – 24 Hr and Raw – 48 Hr, the reduction in hardness was significantly higher in *Tamra* vessel than that of stainless steel vessel (P-values = 0.012 & < 0.001 respectively).

B) Source –Tube well

Also, for tube well as source, P-values of paired t tests suggested that, at each of the *rutu* – *Vasant, Varsha, Sharad, Hemant, Shishir, Tamra* vessel showed significantly higher reduction in hardness than stainless steel vessel at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). For *Greeshma rutu,* the reduction in hardness was significantly higher in *Tamra* vessel than that of stainless steel vessel for time intervals Raw – 12 Hr and Raw – 48 Hr (P-values = 0.012 & < 0.001 respectively) but for time interval Raw – 24 Hr, the difference in reduction was insignificant (P – value = 0.091).

iv) pH

A) Source –River

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	-0.067	-0.050	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 24 Hr	-0.200	-0.183	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 48 Hr	-0.250	-0.233	-0.017	[-0.096 , 0.062]	-0.542	0.611
Greeshma	6	Raw – 12 Hr	-0.083	-0.050	-0.033	[-0.088 , 0.021]	-1.581	0.175
	6	Raw – 24 Hr	-0.183	-0.167	-0.017	[-0.06 , 0.026]	-1.000	0.363
	6	Raw – 48 Hr	-0.233	-0.200	-0.033	[-0.119 , 0.052]	-1.000	0.363
Varsha	6	Raw – 12 Hr	-0.117	-0.100	-0.017	[-0.06 , 0.026]	-1.000	0.363
	6	Raw – 24 Hr	-0.167	-0.167	0.000	-	-	-
	6	Raw – 48 Hr	-0.333	-0.317	-0.017	[-0.06 , 0.026]	-1.000	0.363
Sharad	6	Raw – 12 Hr	-0.067	-0.033	-0.033	[-0.119 , 0.052]	-1.000	0.363
	6	Raw – 24 Hr	-0.100	-0.083	-0.017	[-0.06 , 0.026]	-1.000	0.363
	6	Raw – 48 Hr	-0.150	-0.117	-0.033	[-0.119 , 0.052]	-1.000	0.363
Hemant	6	Raw – 12 Hr	-0.083	-0.067	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 24 Hr	-0.150	-0.133	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 48 Hr	-0.183	-0.183	0.000	[-0.066 , 0.066]	0.000	1.000
Shishir	6	Raw – 12 Hr	-0.100	-0.117	0.017	[-0.062 , 0.096]	0.542	0.611
	6	Raw – 24 Hr	-0.233	-0.217	-0.017	[-0.139 , 0.106]	-0.349	0.741
	6	Raw – 48 Hr	-0.400	-0.367	-0.033	[-0.191 , 0.125]	-0.542	0.611

B) Source –Tube well

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	-0.100	-0.067	-0.033	[-0.142 , 0.075]	-0.791	0.465
	6	Raw – 24 Hr	-0.183	-0.150	-0.033	[-0.119 , 0.052]	-1.000	0.363
	6	Raw – 48 Hr	-0.250	-0.233	-0.017	[-0.096 , 0.062]	-0.542	0.611
Greeshma	6	Raw – 12 Hr	-0.083	-0.067	-0.017	[-0.06 , 0.026]	-1.000	0.363
	6	Raw – 24 Hr	-0.183	-0.167	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 48 Hr	-0.250	-0.233	-0.017	[-0.06 , 0.026]	-1.000	0.363
Varsha	6	Raw – 12 Hr	-0.067	-0.033	-0.033	[-0.088 , 0.021]	-1.581	0.175
	6	Raw – 24 Hr	-0.150	-0.133	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 48 Hr	-0.217	-0.200	-0.017	[-0.096 , 0.062]	-0.542	0.611
Sharad	6	Raw – 12 Hr	-0.033	-0.017	-0.017	[-0.06 , 0.026]	-1.000	0.363
	6	Raw – 24 Hr	-0.033	-0.017	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 48 Hr	-0.083	-0.050	-0.033	[-0.119 , 0.052]	-1.000	0.363
Hemant	6	Raw – 12 Hr	-0.050	-0.033	-0.017	[-0.06 , 0.026]	-1.000	0.363
	6	Raw – 24 Hr	-0.100	-0.067	-0.033	[-0.088 , 0.021]	-1.581	0.175
	6	Raw – 48 Hr	-0.167	-0.150	-0.017	[-0.12 , 0.087]	-0.415	0.695
Shishir	6	Raw – 12 Hr	-0.083	-0.067	-0.017	[-0.096 , 0.062]	-0.542	0.611
	6	Raw – 24 Hr	-0.150	-0.117	-0.033	[-0.119 , 0.052]	-1.000	0.363
	6	Raw – 48 Hr	-0.200	-0.150	-0.050	[-0.138 , 0.038]	-1.464	0.203

A) Source –River

For river as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir* reduction in pH for water stored in *Tamra* vessel and Stainless steel vessel was not significantly different (all P-value> 0.05) i.e. equal.

B) Source –Tube well

Also, for tube well as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir* reduction in pH for water stored in *Tamra* vessel and Stainless steel vessel was not significantly different (all P-value> 0.05) i.e. equal.

v) Total Suspended Solids (TSS)

A) Source –River

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	0.083	0.083	0.000	[-0.094 , 0.094]	0.000	1.000
	6	Raw – 24 Hr	0.183	0.183	0.000	[-0.176 , 0.176]	0.000	1.000
	6	Raw – 48 Hr	0.300	0.283	0.017	[-0.138 , 0.171]	0.277	0.793
Greeshma	6	Raw – 12 Hr	0.117	0.100	0.017	[-0.026 , 0.06]	1.000	0.363
	6	Raw – 24 Hr	0.167	0.167	0.000	[-0.148 , 0.148]	0.000	1.000
	6	Raw – 48 Hr	0.267	0.283	-0.017	[-0.139 , 0.106]	-0.349	0.741
Varsha	6	Raw – 12 Hr	0.083	0.067	0.017	[-0.062 , 0.096]	0.542	0.611
	6	Raw – 24 Hr	0.133	0.133	0.000	[-0.066 , 0.066]	0.000	1.000
	6	Raw – 48 Hr	0.200	0.183	0.017	[-0.087 , 0.12]	0.415	0.695
Sharad	6	Raw – 12 Hr	0.133	0.100	0.033	[-0.125 , 0.191]	0.542	0.611
	6	Raw – 24 Hr	0.267	0.233	0.033	[-0.138 , 0.205]	0.500	0.638
	6	Raw – 48 Hr	0.333	0.300	0.033	[-0.094 , 0.16]	0.674	0.530
Hemant	6	Raw – 12 Hr	0.083	0.083	0.000	[-0.066 , 0.066]	0.000	1.000
	6	Raw – 24 Hr	0.167	0.150	0.017	[-0.106 , 0.139]	0.349	0.741
	6	Raw – 48 Hr	0.233	0.233	0.000	[-0.066 , 0.066]	0.000	1.000
Shishir	6	Raw – 12 Hr	0.100	0.083	0.017	[-0.026 , 0.06]	1.000	0.363
	6	Raw – 24 Hr	0.133	0.133	0.000	[0 , 0]	-	-
	6	Raw – 48 Hr	0.233	0.217	0.017	[-0.062 , 0.096]	0.542	0.611

B) Source –Tube well

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	0.033	0.017	0.017	[-0.123 , 0.156	0.307	0.771
	6	Raw – 24 Hr	0.117	0.117	0.000	[-0.094 , 0.094	0.000	1.000
	6	Raw – 48 Hr	0.083	0.083	0.000	[0 , 0]	-	-
Greeshma	6	Raw – 12 Hr	0.217	0.217	0.000	[-0.115 , 0.115	0.000	1.000
	6	Raw – 24 Hr	0.350	0.333	0.017	[-0.062 , 0.096	0.542	0.611
	6	Raw – 48 Hr	0.400	0.383	0.017	[-0.026 , 0.06]	1.000	0.363
Varsha	6	Raw – 12 Hr	0.267	0.283	-0.017	[-0.096 , 0.062	-0.542	0.611
	6	Raw – 24 Hr	0.283	0.267	0.017	[-0.087 , 0.12]	0.415	0.695
	6	Raw – 48 Hr	0.317	0.333	-0.017	[-0.096 , 0.062	-0.542	0.611
Sharad	6	Raw – 12 Hr	0.100	0.083	0.017	[-0.026 , 0.06]	1.000	0.363
	6	Raw – 24 Hr	0.133	0.133	0.000	[-0.148 , 0.148	0.000	1.000
	6	Raw – 48 Hr	0.217	0.217	0.000	[-0.066 , 0.066	0.000	1.000
Hemant	6	Raw – 12 Hr	0.117	0.100	0.017	[-0.026 , 0.06]	1.000	0.363
	6	Raw – 24 Hr	0.300	0.300	0.000	[0 , 0]	-	-
	6	Raw – 48 Hr	0.383	0.400	-0.017	[-0.06 , 0.026]	-1.000	0.363
Shishir	6	Raw – 12 Hr	0.133	0.150	-0.017	[-0.096 , 0.062	-0.542	0.611
	6	Raw – 24 Hr	0.333	0.317	0.017	[-0.062 , 0.096	0.542	0.611
	6	Raw – 48 Hr	0.450	0.433	0.017	[-0.087 , 0.12]	0.415	0.695

A) Source –River

For river as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir* reduction in TSS for water stored in *Tamra* vessel and Stainless steel vessel was not significantly different (all P-value> 0.05) i.e. equal.

B) Source –Tube well

Also, for tube well as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir* reduction in TSS for water stored in *Tamra* vessel and Stainless steel vessel was not significantly different (all P-value> 0.05) i.e. equal.

vi) Total Dissolved Solids (TDS)

A) Source –River

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	20.000	3.667	16.333	[14.066 , 18.6]	18.520	< 0.001
	6	Raw – 24 Hr	33.167	7.333	25.833	[22.909 , 28.758]	22.706	< 0.001
	6	Raw – 48 Hr	46.167	8.833	37.333	[31.013 , 43.653]	15.185	< 0.001
Greeshma	6	Raw – 12 Hr	17.167	1.333	15.833	[13.495 , 18.172]	17.403	< 0.001
	6	Raw – 24 Hr	38.500	2.667	35.833	[30.937 , 40.729]	18.813	< 0.001
	6	Raw – 48 Hr	48.167	3.500	44.667	[42.499 , 46.834]	52.968	< 0.001
Varsha	6	Raw – 12 Hr	21.833	5.000	16.833	[12.666 , 21]	10.384	< 0.001
	6	Raw – 24 Hr	38.667	10.500	28.167	[23.094 , 33.24]	14.273	< 0.001
	6	Raw – 48 Hr	47.500	13.333	34.167	[28.798 , 39.535]	16.361	< 0.001
Sharad	6	Raw – 12 Hr	17.667	3.000	14.667	[9.804 , 19.529]	7.754	0.001
	6	Raw – 24 Hr	35.833	6.667	29.167	[22.036 , 36.297]	10.515	< 0.001
	6	Raw – 48 Hr	52.167	9.833	42.333	[39.466 , 45.201]	37.949	< 0.001
Hemant	6	Raw – 12 Hr	14.667	3.833	10.833	[7.422 , 14.245]	8.163	< 0.001
	6	Raw – 24 Hr	31.333	7.167	24.167	[21.828 , 26.505]	26.562	< 0.001
	6	Raw – 48 Hr	43.000	11.167	31.833	[30.026 , 33.641]	45.271	< 0.001
Shishir	6	Raw – 12 Hr	15.667	3.333	12.333	[6.914 , 17.753]	5.850	0.002
	6	Raw – 24 Hr	31.500	6.833	24.667	[20.434 , 28.899]	14.981	< 0.001
	6	Raw – 48 Hr	49.833	10.667	39.167	[37.025 , 41.309]	47.000	< 0.001

B) Source –Tube well

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	16.333	1.833	14.500	[13.053 , 15.947	25.767	< 0.001
	6	Raw – 24 Hr	33.000	7.667	25.333	[21.658 , 29.009	17.718	< 0.001
	6	Raw – 48 Hr	44.833	11.000	33.833	[29.562 , 38.105	20.361	< 0.001
Greeshma	6	Raw – 12 Hr	17.000	4.167	12.833	[8.997 , 16.67]	8.598	< 0.001
	6	Raw – 24 Hr	40.167	8.000	32.167	[29.736 , 34.598	34.012	< 0.001
	6	Raw – 48 Hr	49.833	10.833	39.000	[35.073 , 42.927	25.531	< 0.001
Varsha	6	Raw – 12 Hr	14.833	3.833	11.000	[10.336 , 11.664	42.603	< 0.001
	6	Raw – 24 Hr	19.833	7.167	12.667	[11.233 , 14.1]	22.709	< 0.001
	6	Raw – 48 Hr	21.667	10.500	11.167	[9.622 , 12.711]	18.582	< 0.001
Sharad	6	Raw – 12 Hr	22.000	4.500	17.500	[14.477 , 20.523	14.879	< 0.001
	6	Raw – 24 Hr	44.500	8.667	35.833	[31.773 , 39.893	22.688	< 0.001
	6	Raw – 48 Hr	50.167	13.833	36.333	[32.369 , 40.297	23.562	< 0.001
Hemant	6	Raw – 12 Hr	12.333	3.000	9.333	[8.062 , 10.604]	18.878	< 0.001
	6	Raw – 24 Hr	28.833	6.167	22.667	[18.231 , 27.103	13.135	< 0.001
	6	Raw – 48 Hr	43.333	8.500	34.833	[32.313 , 37.353	35.531	< 0.001
Shishir	6	Raw – 12 Hr	17.000	4.167	12.833	[4.271 , 21.396]	3.853	0.012
	6	Raw – 24 Hr	32.500	6.333	26.167	[23.736 , 28.598	27.668	< 0.001
	6	Raw – 48 Hr	43.167	9.000	34.167	[31.828 , 36.505	37.553	< 0.001

A) Source –River

For river as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir, Tamra* vessel showed significantly higher reduction in TDS than stainless steel vessel at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-value < 0.05)

B) **Source –Tube well**

Also, for tube well as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir, Tamra* vessel showed significantly higher reduction in TDS than stainless steel vessel at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05)

vii) Most Probable number (MPN)

A) Source –River

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	Diff			
Vasant	6	Raw – 12 Hr	386.333	28.167	358.167	[349.946 , 366.388]	111.994	< 0.001
	6	Raw – 24 Hr	394.167	50.333	343.833	[339.168 , 348.499]	189.434	< 0.001
	6	Raw – 48 Hr	399.667	53.833	345.833	[339.628 , 352.039]	143.257	< 0.001
Greeshma	6	Raw – 12 Hr	422.667	20.500	402.167	[392.38 , 411.953]	105.634	< 0.001
	6	Raw – 24 Hr	431.667	41.167	390.500	[377.363 , 403.637]	76.412	< 0.001
	6	Raw – 48 Hr	443.167	50.167	393.000	[376.81 , 409.19]	62.399	< 0.001
Varsha	6	Raw – 12 Hr	545.167	28.000	517.167	[499.994 , 534.339]	77.415	< 0.001
	6	Raw – 24 Hr	560.000	63.333	496.667	[479.325 , 514.008]	73.622	< 0.001
	6	Raw – 48 Hr	575.333	68.333	507.000	[488.606 , 525.394]	70.855	< 0.001
Sharad	6	Raw – 12 Hr	204.833	13.167	191.667	[187.331 , 196.002]	113.644	< 0.001
	6	Raw – 24 Hr	209.167	22.500	186.667	[184.04 , 189.294]	182.652	< 0.001
	6	Raw – 48 Hr	211.667	29.167	182.500	[179.55 , 185.45]	159.047	< 0.001
Hemant	6	Raw – 12 Hr	375.000	16.833	358.167	[353.454 , 362.879]	195.364	< 0.001
	6	Raw – 24 Hr	380.333	34.667	345.667	[341.932 , 349.402]	237.904	< 0.001
	6	Raw – 48 Hr	386.833	41.167	345.667	[339.141 , 352.192]	136.165	< 0.001
Shishir	6	Raw – 12 Hr	373.667	12.833	360.833	[358.495 , 363.172]	396.597	< 0.001
	6	Raw – 24 Hr	379.500	30.333	349.167	[348.377 , 349.957]	1136.173	< 0.001
	6	Raw – 48 Hr	383.333	38.833	344.500	[340.819 , 348.181]	240.609	< 0.001

B) Source –Tube well

Rutu	N	Comparison	Mean reduction			95% C.I.	Paired 't'	P-value (two tailed)
			Tamra	Steel	diff			
Vasant	6	Raw – 12 Hr	364.000	15.833	348.167	[337.601 , 358.732]	84.706	< 0.001
	6	Raw – 24 Hr	372.667	39.500	333.167	[330.924 , 335.409]	381.889	< 0.001
	6	Raw – 48 Hr	380.167	50.000	330.167	[327.242 , 333.091]	290.196	< 0.001
Greeshma	6	Raw – 12 Hr	388.333	28.167	360.167	[355.844 , 364.489]	214.181	< 0.001
	6	Raw – 24 Hr	398.833	52.500	346.333	[343.971 , 348.696]	376.885	< 0.001
	6	Raw – 48 Hr	406.333	61.833	344.500	[340.819 , 348.181]	240.609	< 0.001
Varsha	6	Raw – 12 Hr	462.500	23.167	439.333	[431.631 , 447.036]	146.626	< 0.001
	6	Raw – 24 Hr	474.000	49.500	424.500	[423.215 , 425.785]	849.000	< 0.001
	6	Raw – 48 Hr	484.500	57.167	427.333	[424.791 , 429.875]	432.162	< 0.001
Sharad	6	Raw – 12 Hr	192.667	13.667	179.000	[174.354 , 183.646]	99.038	< 0.001
	6	Raw – 24 Hr	201.833	22.667	179.167	[177.359 , 180.974]	254.799	< 0.001
	6	Raw – 48 Hr	205.667	32.500	173.167	[168.947 , 177.386]	105.494	< 0.001
Hemant	6	Raw – 12 Hr	369.833	19.667	350.167	[345.316 , 355.018]	185.559	< 0.001
	6	Raw – 24 Hr	378.000	43.167	334.833	[333.438 , 336.228]	617.059	< 0.001
	6	Raw – 48 Hr	386.000	54.833	331.167	[327.955 , 334.378]	265.051	< 0.001
Shishir	6	Raw – 12 Hr	364.667	21.333	343.333	[333.275 , 353.392]	87.743	< 0.001
	6	Raw – 24 Hr	374.667	40.000	334.667	[333.396 , 335.938]	676.897	< 0.001
	6	Raw – 48 Hr	381.500	49.833	331.667	[327.648 , 335.686]	212.135	< 0.001

A) Source –River

For river as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir, Tamra* vessel showed significantly higher reduction in MPN than stainless steel vessel at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-value < 0.05)

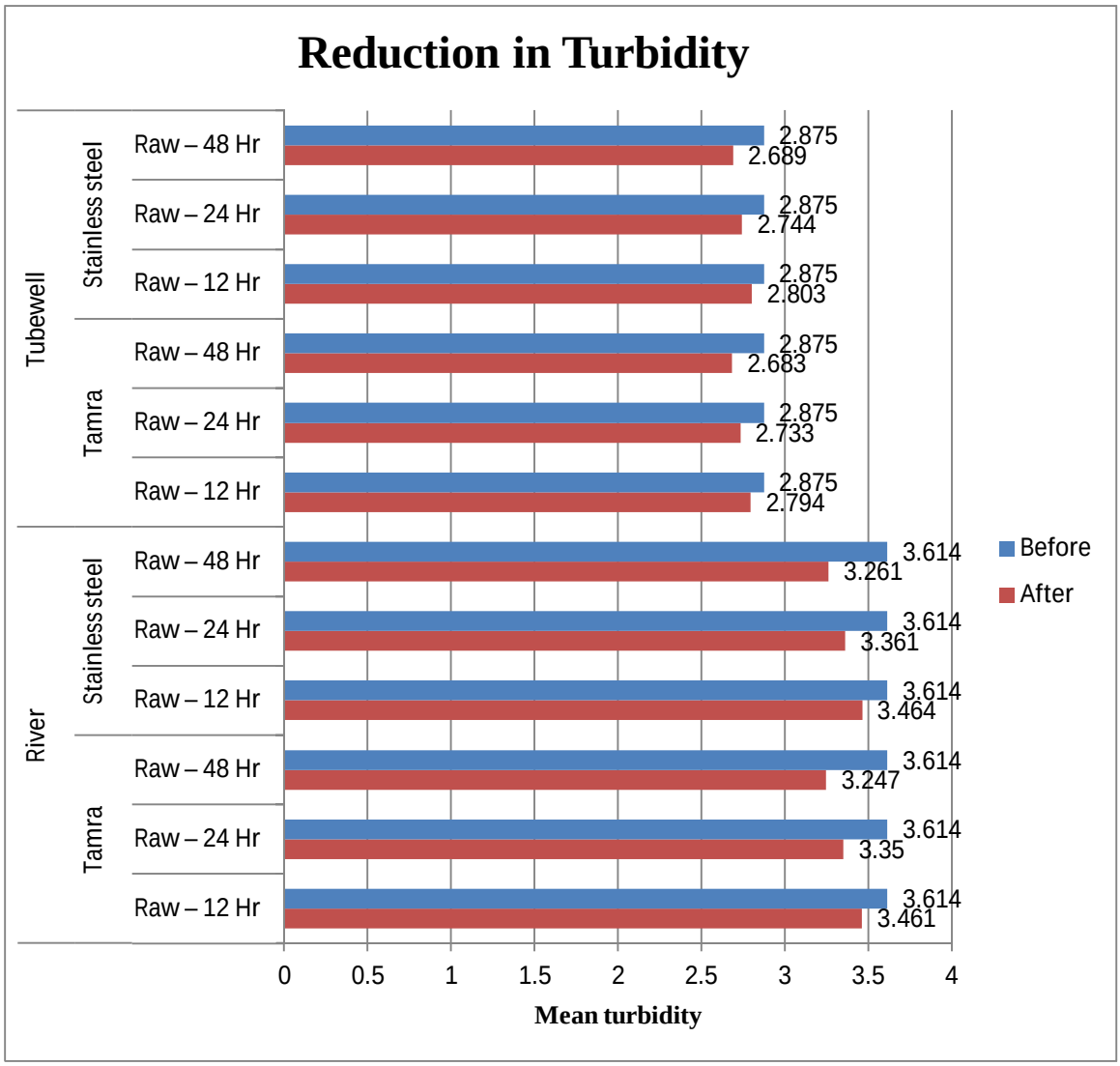
B) Source –Tube well

Also, for tube well as source, P-values of paired t tests suggested that, at each of the *rutu – Vasant, Greeshma, Varsha, Sharad, Hemant* & *Shishir Tamra* vessel showed significantly higher reduction in MPN than stainless steel vessel at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05)

OBJECTIVE PARAMETER - OVER ALL ANALYSIS – SOURCE WISE

1) WITHIN GROUP EFFECT:-

i) Turbidity -



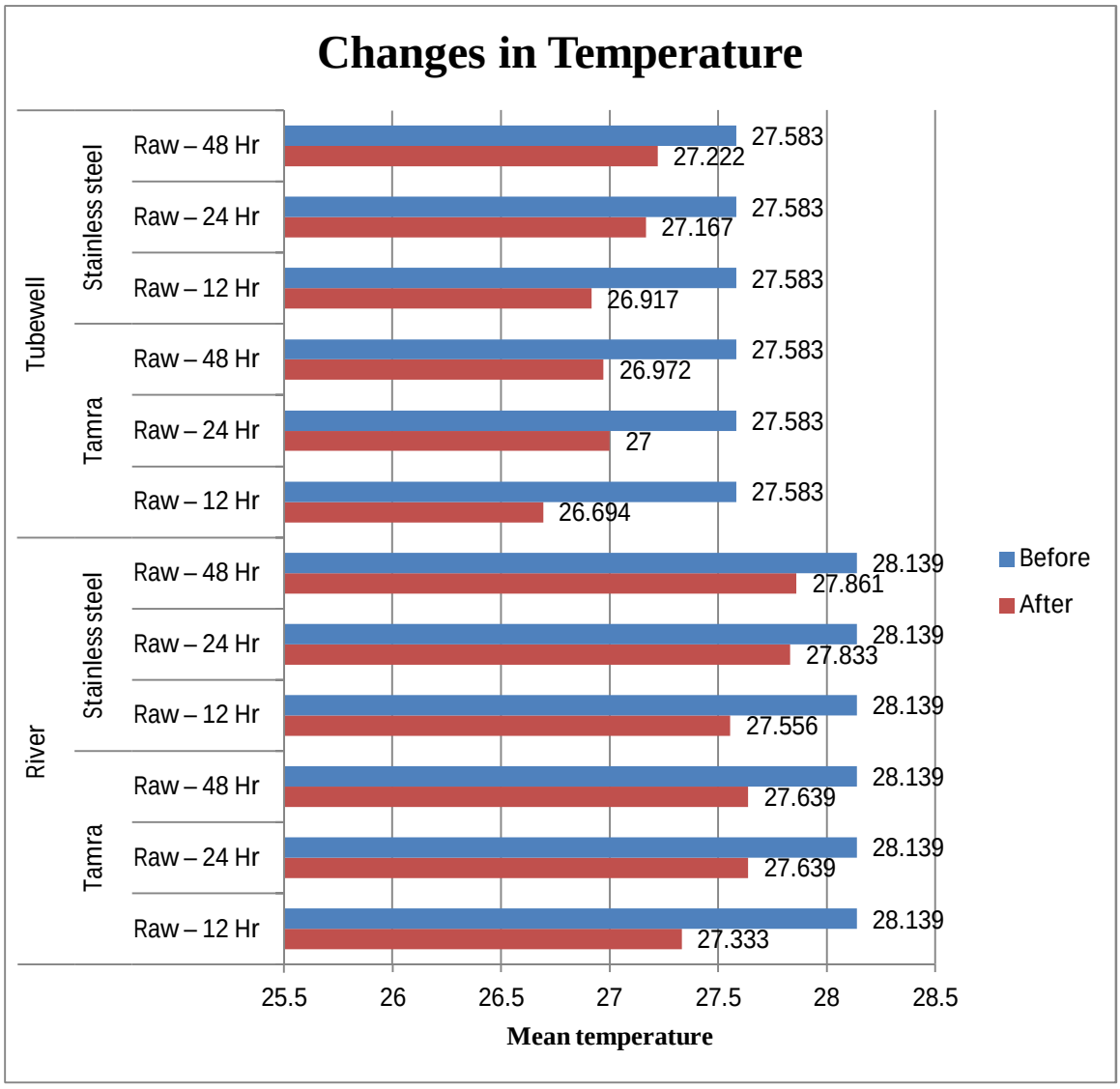
A) Source –River Vessel – *Tamra* & Stainless steel

For River samples, water stored in *Tamra* vessel as well as Stainless steel vessel showed significant reduction in turbidity at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

B) Source –Tube well Vessel – *Tamra* & Stainless steel

Also, for tube well samples water stored in both *Tamra* and Stainless steel vessels showed statistically significant reduction in turbidity at each of the time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

ii) Temperature -



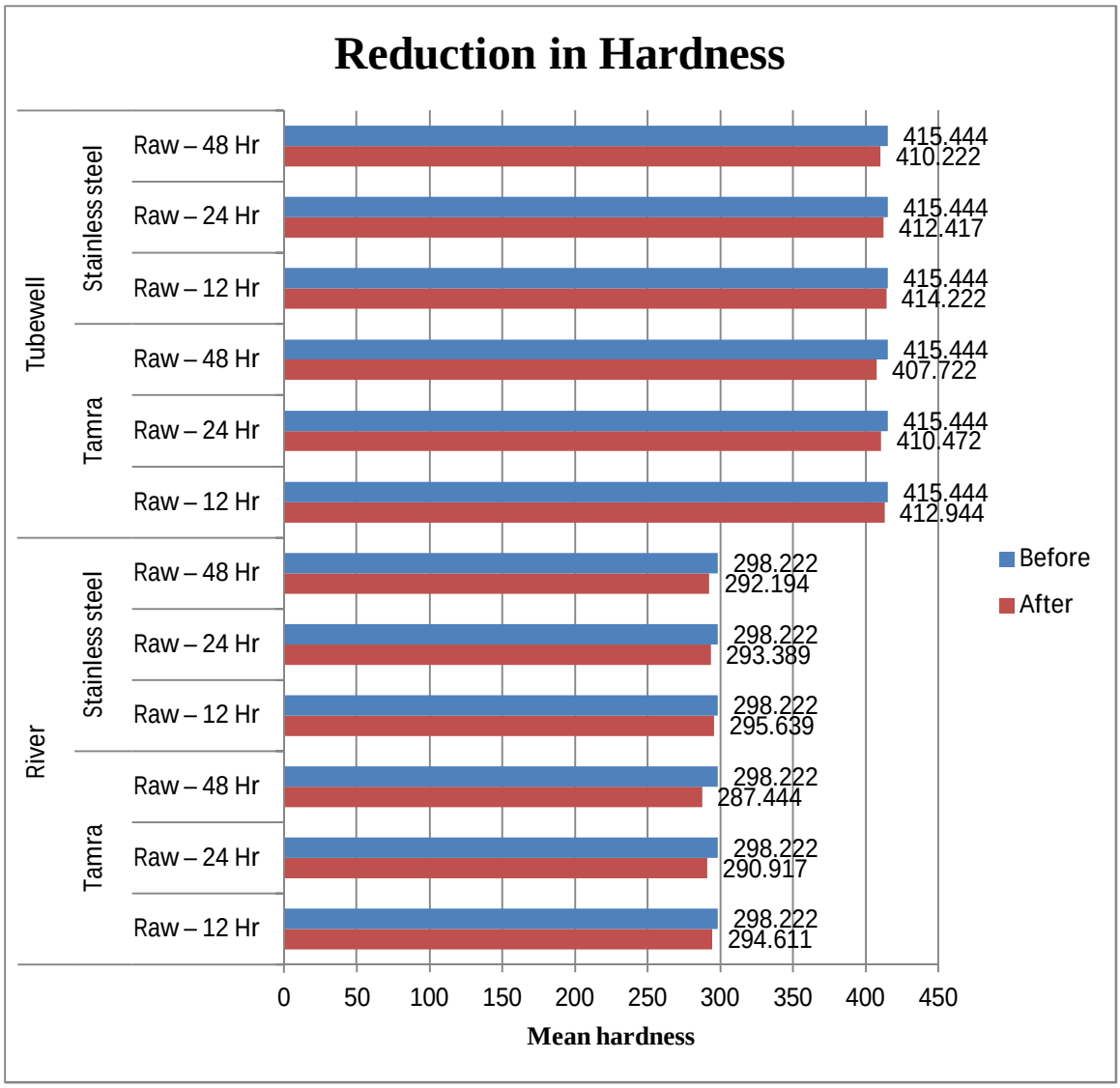
A) Source –River Vessel – *Tamra* & Stainless steel

For River samples, water stored in *Tamra* vessel showed significant reduction in temperature at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). Water stored in Stainless steel vessel showed significant reduction in temperature for time interval Raw – 12 Hr & Raw – Raw – 24 Hr (P-values < 0.001 & 0.039 respectively) but for time interval Raw – 48 Hr, the reduction was insignificant (P-value = 0.223)

B) Source –Tube well Vessel – *Tamra* & Stainless steel

Also, for tube well samples water stored in *Tamra* showed statistically significant reduction in temperature at each of the time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05) while Water stored in Stainless steel vessel showed significant reduction in temperature for time interval Raw – 12 Hr & Raw – Raw – 24 Hr (P-values < 0.001 & 0.005 respectively) but for time interval Raw – 48 Hr, the reduction was insignificant (P-value = 0.108)

iii)Hardness-



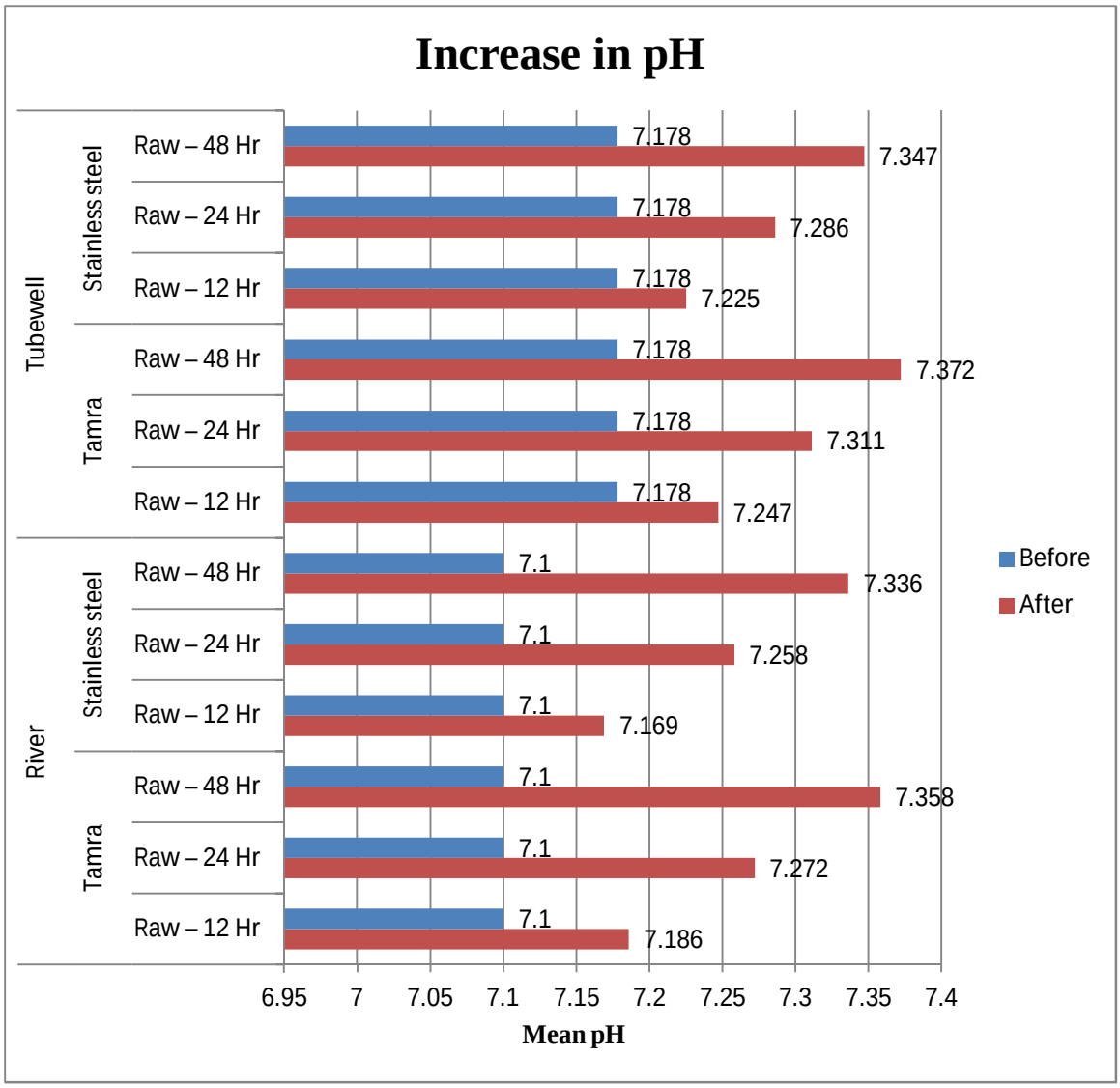
A) Source –River Vessel – *Tamra* & Stainless steel

For River samples, water stored in *Tamra* vessel as well as Stainless steel vessel showed significant reduction in hardness at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

B) Source –Tube well Vessel – *Tamra* & Stainless steel

Also, for Tube well samples water stored in both *Tamra* and Stainless steel vessels showed statistically significant reduction in hardness at each of the time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

iv) pH-



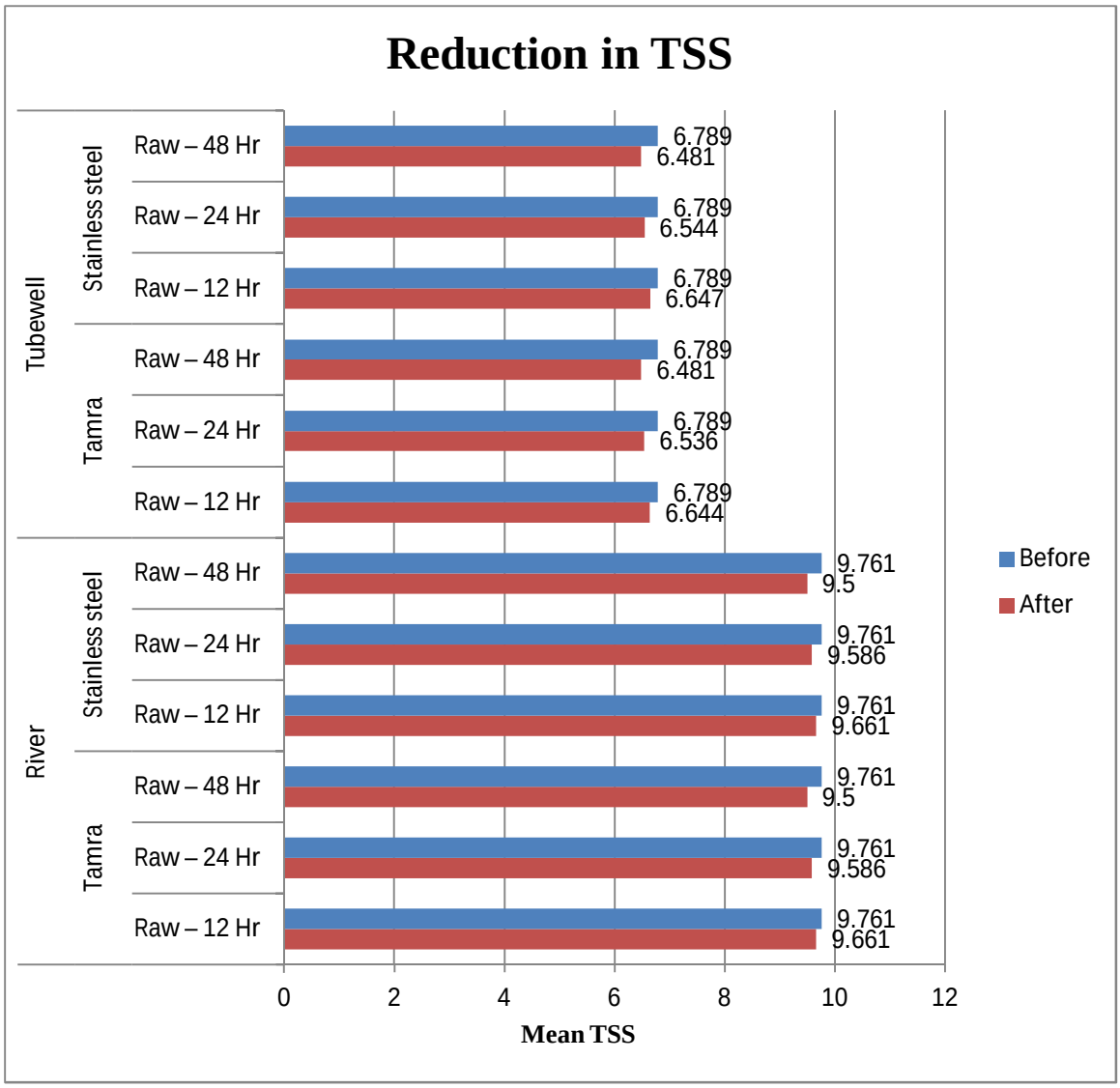
A) Source –River Vessel – *Tamra* & Stainless steel

For River samples, there was significant increase in pH for water stored in *Tamra* vessel as well as stainless steel vessel, for any of the time intervals Raw – 12 Hr Raw – 24 Hr and Raw – 48 Hr (All P-values < 0.001).

B) Source –Tube well Vessel – *Tamra* & Stainless steel

For tube well samples, there was significant increase in pH for water stored in *Tamra* vessel as well as stainless steel vessel, for any of the time intervals Raw – 12 Hr Raw – 24 Hr and Raw – 48 Hr (All P-values < 0.001).

v) Total Suspended Solids (TSS)-



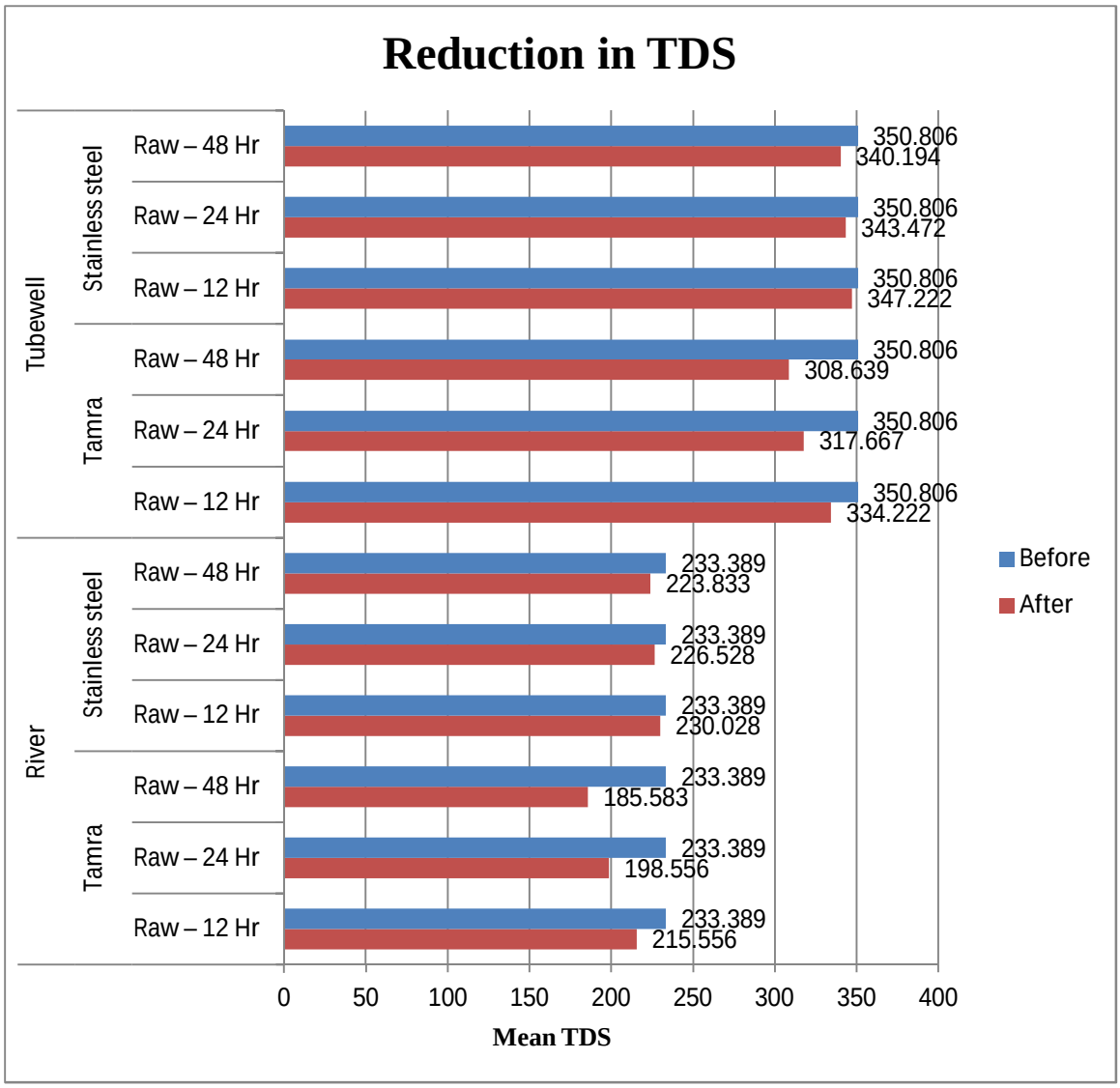
A) Source –River Vessel– *Tamra* & Stainless steel

For River samples, water stored in *Tamra* vessel as well as Stainless steel vessel showed significant reduction in TSS at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

B) Source –Tube well Vessel – *Tamra* & Stainless steel

Also, for tube well samples water stored in both *Tamra* and Stainless steel vessels showed statistically significant reduction in TSS at each of the time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

vi) Total Dissolved Solids (TDS) -



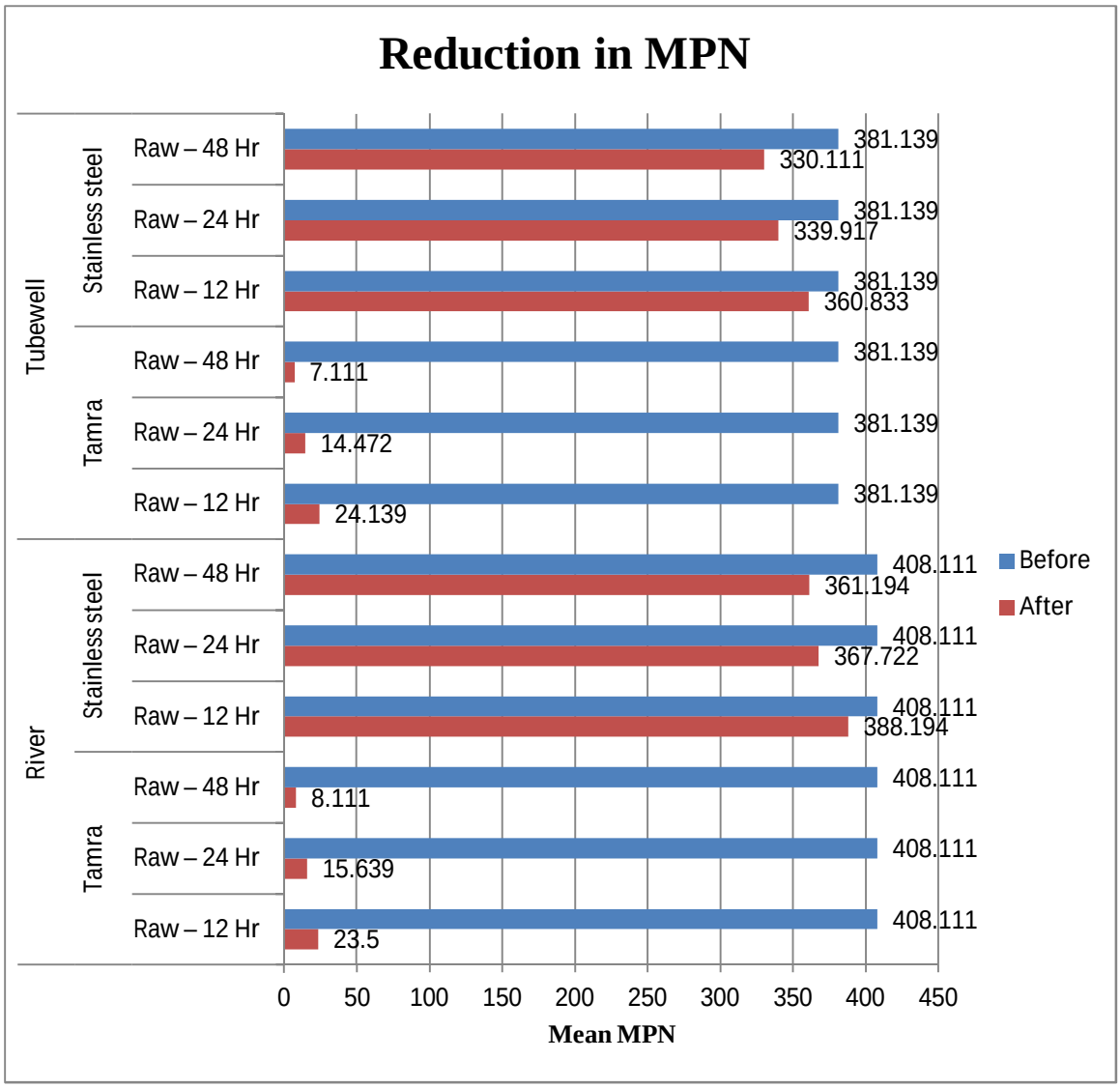
A) Source –River Vessel– *Tamra* & Stainless steel

For River samples, water stored in *Tamra* vessel as well as Stainless steel vessel showed significant reduction in TDS at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

B) Source –Tube well Vessel– *Tamra* & Stainless steel

Also, for tube well samples water stored in both *Tamra* and Stainless steel vessels showed statistically significant reduction in TDS at each of the time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

vi) Most Probable Number (MPN)



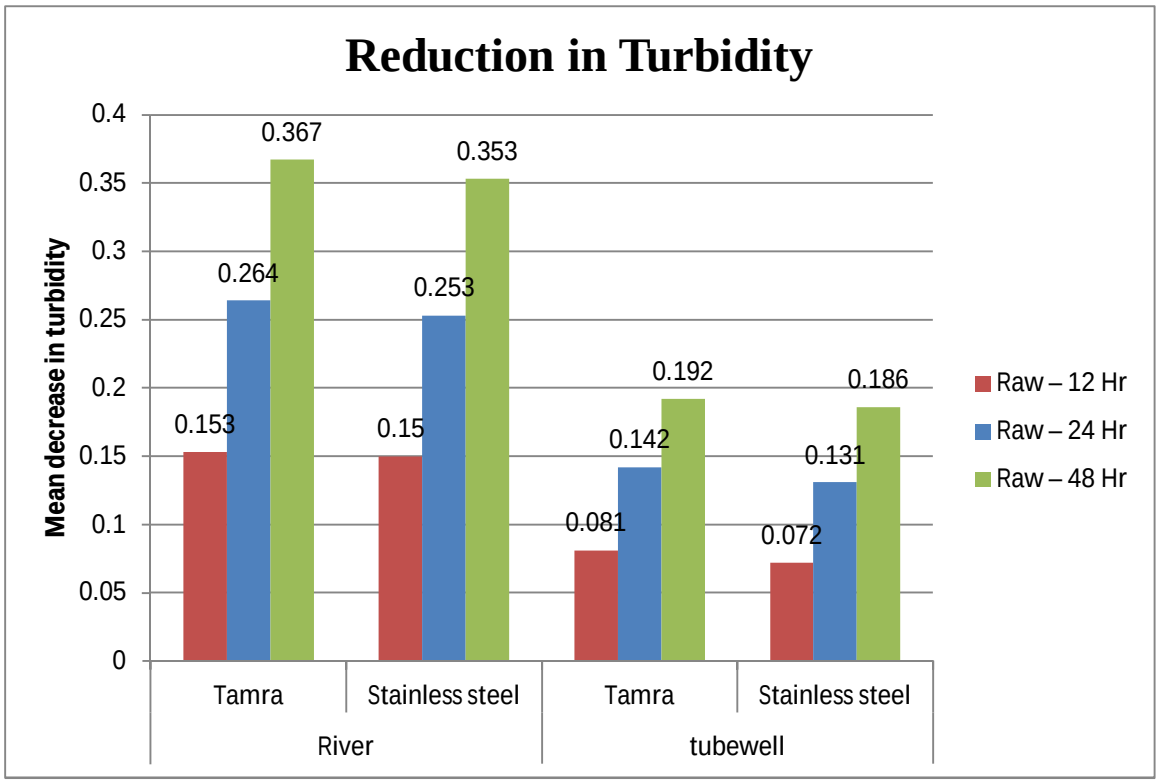
A) Source –River Vessel – *Tamra* & Stainless steel

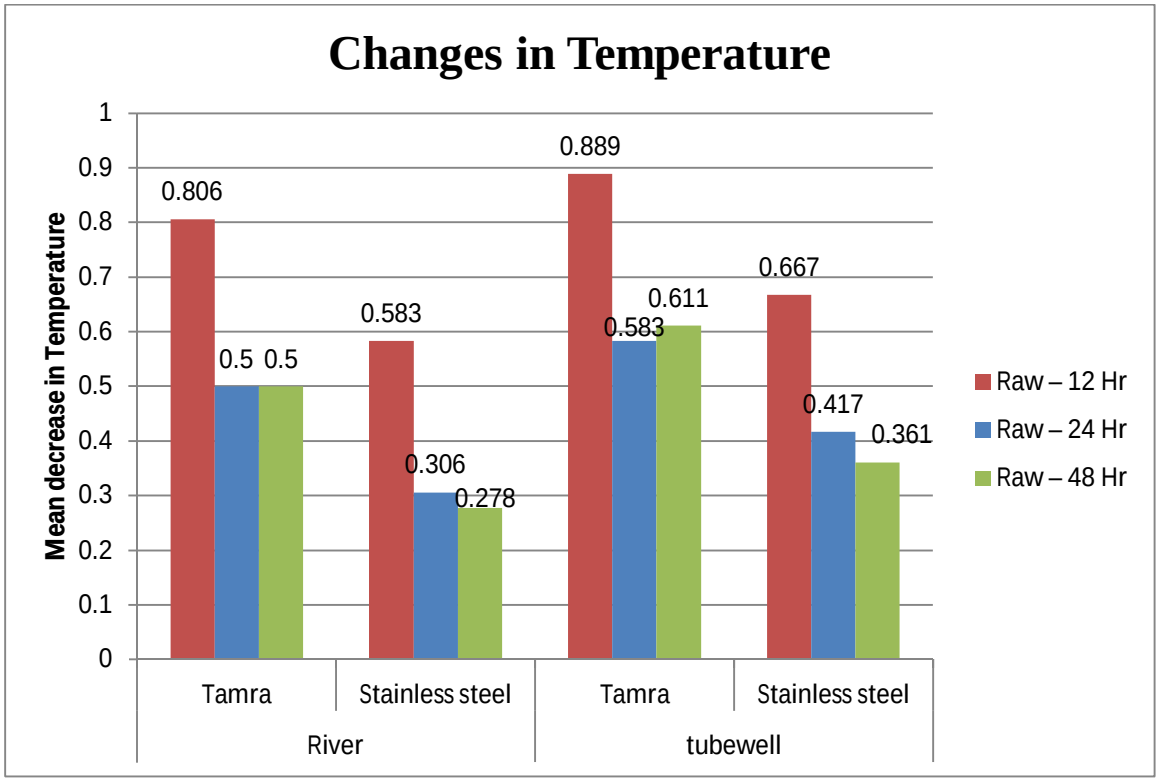
For River samples, water stored in *Tamra* vessel as well as Stainless steel vessel showed significant reduction in MPN at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

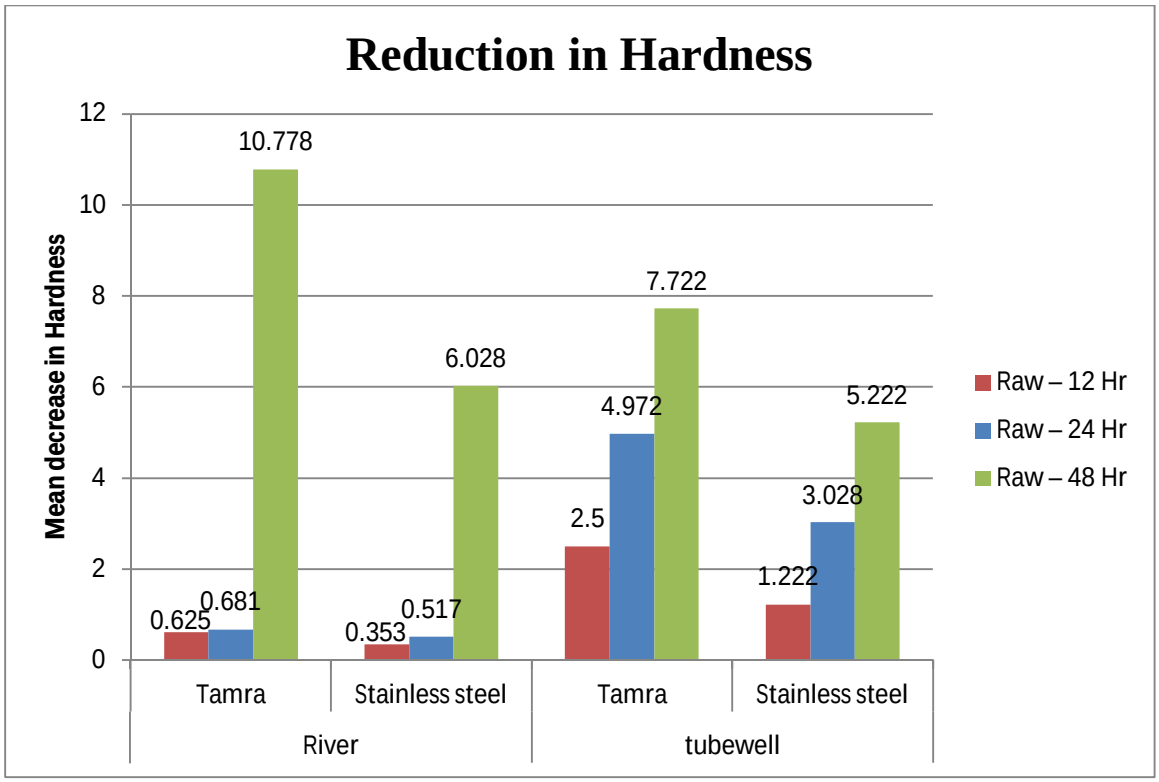
B) Source –Tube well Vessel – *Tamra* & Stainless steel

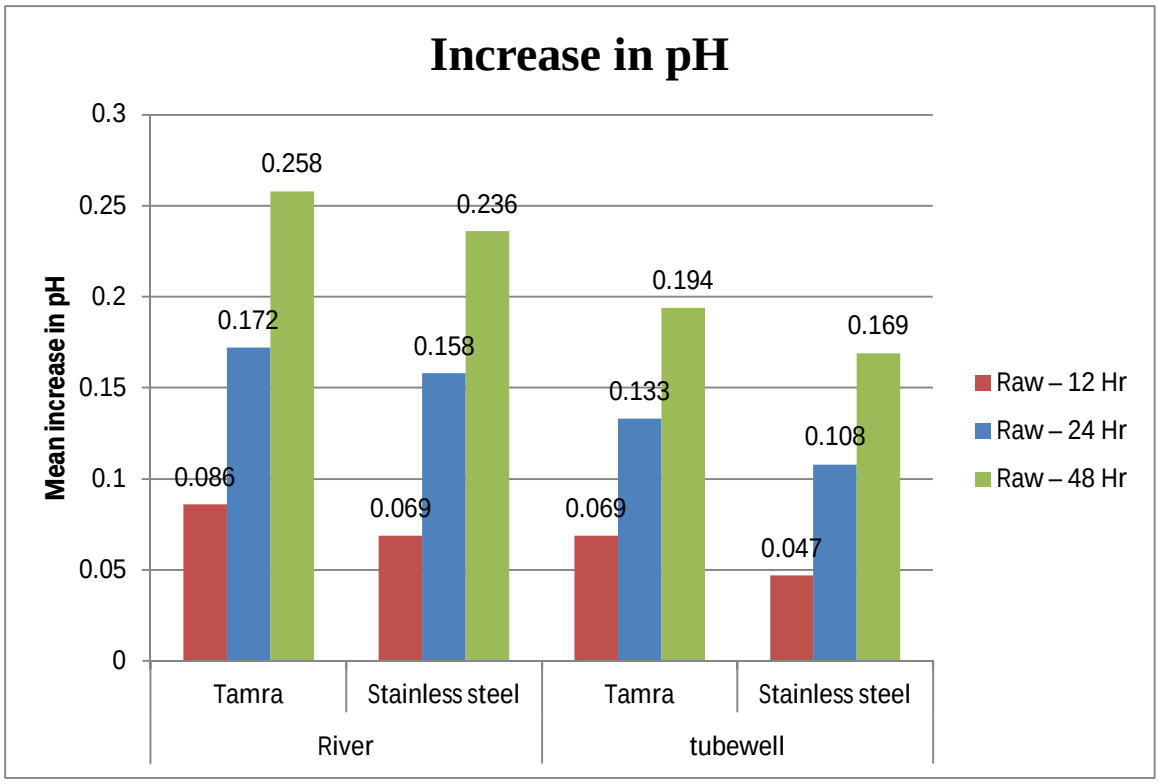
Also, for Tube well samples water stored in both *Tamra* and Stainless steel vessels showed statistically significant reduction in MPN at each of the time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.001).

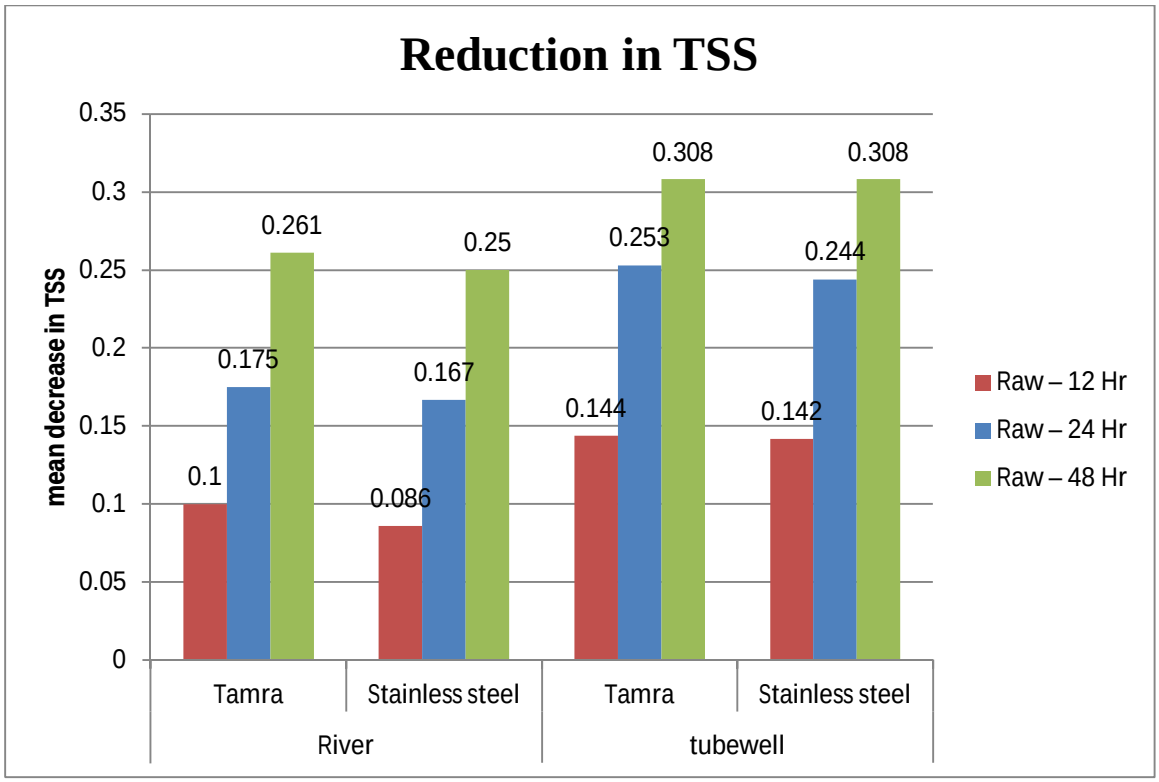
2) BETWEEN GROUP EFFECT:-

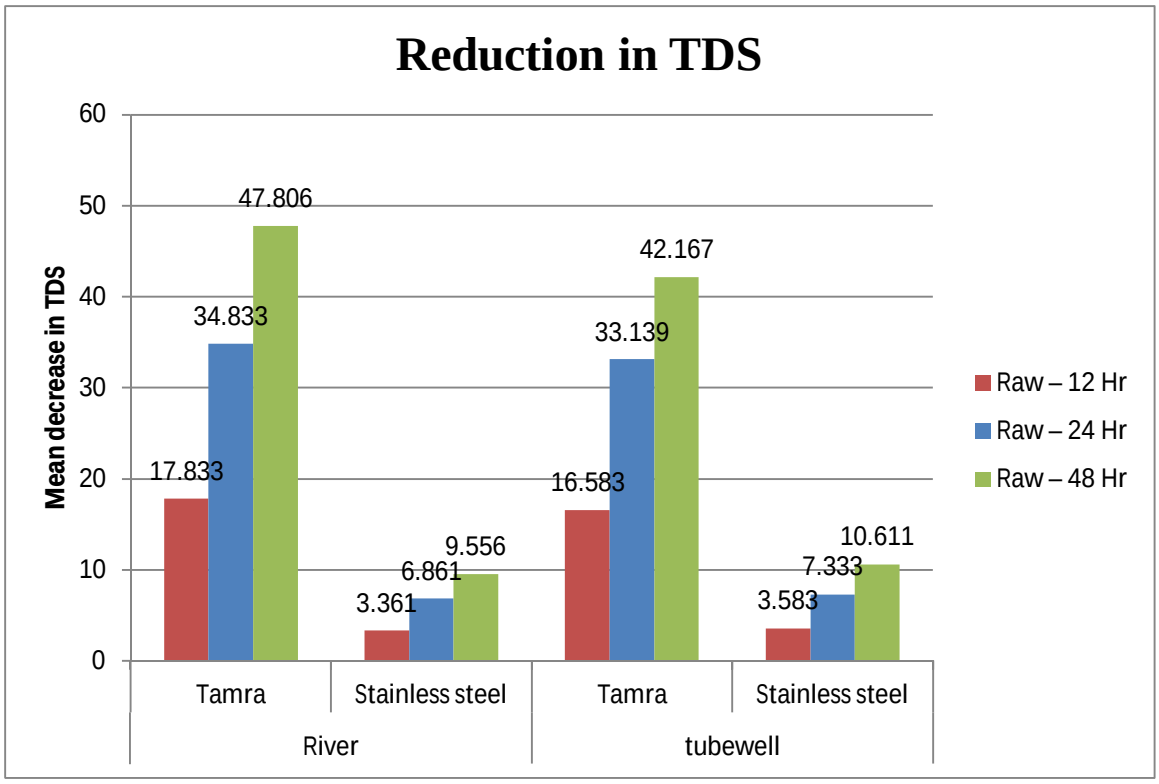


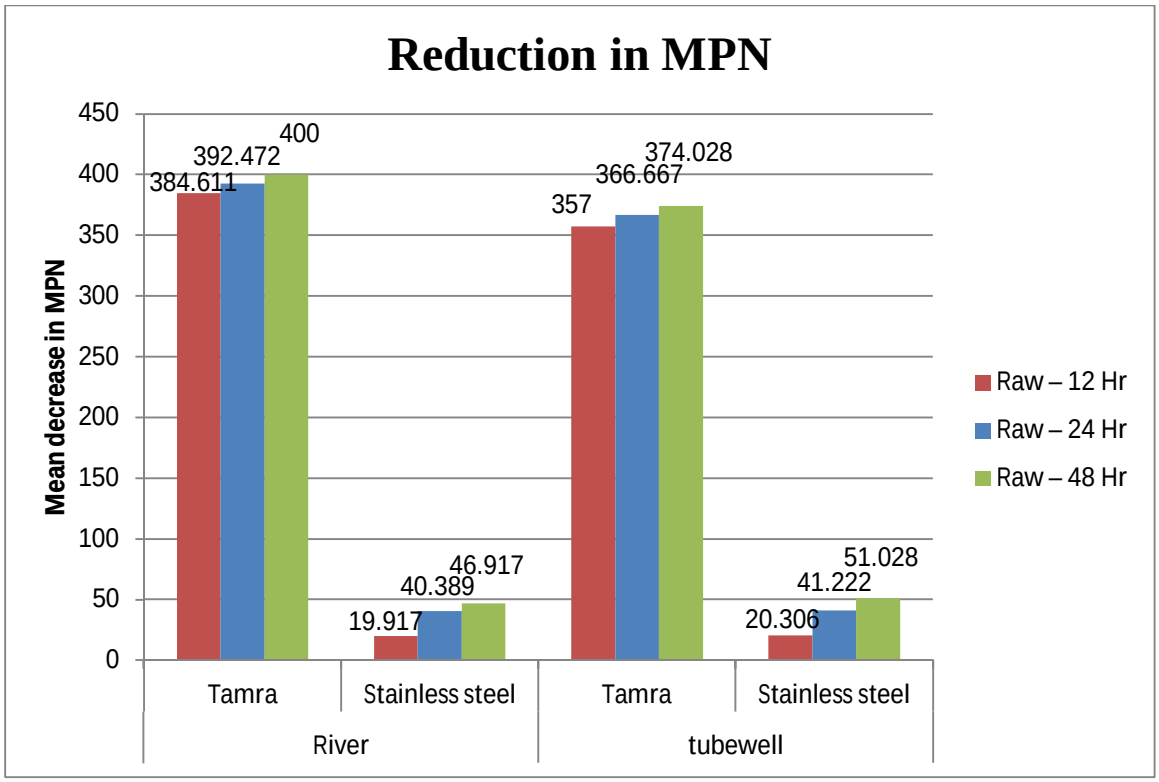



Reduction in Hardness
Mean decrease in Hardness
12
10
8
6
4
2
0
10.778
7.722
6.028
5.222
4.972
3.028
2.5
1.222
0.681
0.625
0.517
0.353
Tamra
Stainless steel
Tamra
Stainless steel
River
tubewell
Raw – 12 Hr
Raw – 24 Hr
Raw – 48 Hr


Increase in pH
Mean increase in pH
0.3
0.25
0.2
0.15
0.1
0.05
0
0.258
0.236
0.194
0.172
0.169
0.158
0.133
0.108
0.086
0.069
0.069
0.047
Tamra
Stainless steel
Tamra
Stainless steel
River
tubewell
Raw – 12 Hr
Raw – 24 Hr
Raw – 48 Hr


Reduction in TSS
mean decrease in TSS
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1
0.175
0.261
0.086
0.167
0.25
0.144
0.253
0.308
0.142
0.244
0.308
Tamra
Stainless steel
Tamra
Stainless steel
River
tubewell
Raw – 12 Hr
Raw – 24 Hr
Raw – 48 Hr


Reduction in TDS
Mean decrease in TDS
60
50
40
30
20
10
0
17.833
34.833
47.806
3.361
6.861
9.556
16.583
33.139
42.167
3.583
7.333
10.611
Tamra
Stainless steel
Tamra
Stainless steel
River
tubewell
Raw – 12 Hr
Raw – 24 Hr
Raw – 48 Hr



A) Source – River

For river as source, P-values of paired t tests suggested that, reduction in values of parameters - Turbidity temperature, and TSS for water stored in *Tamra* vessel and Stainless steel vessel were not significantly different at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr. (All P-values > 0.05). Whereas reduction in values of parameters - Hardness, TDS and MPN for water stored in *Tamra* vessel was significantly higher than that for water stored in Stainless steel vessel at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr. (All P-values < 0.05). The increase in pH for water stored in Stainless steel vessel and *Tamra* vessel was not insignificantly different for all time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 (All P-values > 0.05).

B) Source –Tube well

With Tube well samples, P-values of paired t tests suggested that, reduction in values of parameters – Turbidity and TSS for water stored in *Tamra* vessel and Stainless steel vessel were not significantly different at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr. (All P-values > 0.05). Temperature was significantly reduced for time interval Raw – 12 Hr and

Raw – 48 Hr (P-values = 0.040 & 0.042 respectively) while for time interval, Raw – 24 Hr the reduction was insignificant (P-value = 0.106). Whereas reduction in values of parameters - Hardness, TDS and MPN for water stored in *Tamra* vessel was significantly higher than that for water stored in Stainless steel vessel at every time interval viz. Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr. (All P-values < 0.05). The increase in pH of water stored in *Tamra* vessel and Stainless steel vessel was not significant different for all time intervals Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr.

SUBJECTIVE PARAMETER ANALYSIS

1) WITHIN GROUP EFFECT

i) Colour

a) Source – River Vessel - *Tamra*

Rutu	**N**	**Comparison**	**(non-zero) Median difference (bef – aft)**	**Wilcoxon signed rank test T^+**	**P-value**
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Varsha	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

Source – River Vessel – Stainless steel

Rutu	**N**	**Comparison**	**(non-zero) Median difference (bef – aft)**	**Wilcoxon signed rank test T^+**	**P-value**
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Varsha	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

b) Source –Tube well Vessel - *Tamra*

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

Source –Tube well Vessel – Stainless steel

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

A) Source – River Vessel - *Tamra* & Stainless steel

For river water, in *Greeshma* and *Varsha rutu*, there was significant improvement in colour for water stored in *Tamra* vessel as well as Stainless steel vessel for all three time intervals – Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05).For remaining all *rutus*, colour remained unchanged with both *Tamra* vessel and Stainless steel vessel

B) Source –Tube well Vessel – *Tamra* & Stainless steel

For tube well water, in *Varsha rutu*, there was significant improvement in colour for water stored in *Tamra* vessel as well as Stainless steel vessel for all three time intervals – Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). For remaining all *rutus*, colour remained unchanged with both *Tamra* vessel and stainless steel vessel.

ii) Shuddhi

a) Source –River Vessel - *Tamra*

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Varsha	6	0 hr – 12 hr	1.5	21	0.032
	6	0 hr – 24 hr	2	21	0.026
	6	0 h – 48 hr	2	21	0.026
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

Source –River Vessel – Stainless steel

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Varsha	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

b) **Source –Tube well Vessel -** ***Tamra***

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

Source –Tube well Vessel – Stainless steel

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

A) Source –River Vessel - *Tamra* & Stainless steel

For river water, in *Greeshma* and *Varsha rutu*, there was significant improvement in *Shuddhi* for water stored in *Tamra* vessel as well as Stainless steel vessel for all three time intervals – Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). For remaining all *rutus, Shuddhi* remained unchanged with both *Tamra* vessel and stainless steel vessel

B) Source –Tube well Vessel – *Tamra* & Stainless steel

For tube well water, in *Varsha rutu*, there was significant improvement in *Shuddhi* for water stored in *Tamra* vessel as well as Stainless steel vessel for all three time intervals – Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (all P-values < 0.05). For remaining all *rutus, Shuddhi* remained unchanged with both *Tamra* vessel and stainless steel vessel

iii) Shitata-

a) Source –River Vessel - *Tamra*

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Greeshma	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

Source –River Vessel – Stainless steel

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Greeshma	6	0 hr – 12 hr	1	21	0.020
	6	0 hr – 24 hr	1	21	0.020
	6	0 h – 48 hr	1	21	0.020
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

b) Source –Tube well Vessel - *Tamra*

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

Source –Tube well Vessel – Stainless steel

Rutu	N	Comparison	(non-zero) Median difference (bef – aft)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

A) Source –River Vessel – *Tamra* & Stainless steel

For river water, in *Vasant* & *Greeshma rutu* there was significant improvement in *Shitata* for water stored in *Tamra* vessel as well as Stainless steel vessel for all three time intervals – Raw – 12 Hr, Raw – 24 Hr and Raw – 48 Hr (P-values = 0.020, 0.020 & 0.020 respectively). For remaining all *rutus, Shitata* remained unchanged with both *Tamra* vessel and stainless steel vessel

B) Source –Tube well Vessel – *Tamra* & Stainless steel

For tube well water, *Shitata* remained unchanged with both *Tamra* vessel and stainless steel vessel for all *rutus*.

iv) Odour

a) Source –River Vessel - *Tamra*

Rutu	Time		0 Hr		d.f.	McNemar chi-square (corrected)	P-value
			1	**2**			
Vasant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Greeshma	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Varsha	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Sharad	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Hemant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Shishir	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			

Source –River Vessel – Stainless steel

Rutu	Time		0 Hr		d.f.	McNemar chi-square (corrected)	P-value
			1	2			
Vasant	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Greeshma	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Varsha	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Sharad	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Hemant	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Shishir	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			

b) Source-Tube well Vessel - *Tamra*

Rutu	Time		0 Hr		d.f.	McNemar chi-square (corrected)	P-value
			1	**2**			
Vasant	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Greeshma	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Varsha	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Sharad	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Hemant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Shishir	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			

Source-Tube well Vessel – Stainless steel

Rutu	Time		0 Hr		d.f.	McNemar chi-square (corrected)	P-value
			1	**2**			
Vasant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Greeshma	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Varsha	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Sharad	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Hemant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Shishir	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			

A) Source –River Vessel – *Tamra* & Stainless steel

There was no change in odour for any sample of river irrespective of vessel (*Tamra* or Stainless steel) and *rutu*.

B) Source-Tube well Vessel - *Tamra* & Stainless steel

There was no change in odour for any sample of tube well irrespective of vessel (*Tamra* or Stainless steel) and *rutu*.

v) ***Gandha***

a) **Source –River Vessel -** ***Tamra***

Rutu	**Time**		**0 Hr**		**d.f.**	**McNemar chi-square (corrected)**	**P-value**
			1	**2**			
Vasant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Greeshma	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Varsha	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Sharad	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Hemant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Shishir	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			

Source River Vessel – Stainless steel

Rutu	Time		0 Hr		d.f.	McNemar chi-square (corrected)	P-value
			1	2			
Vasant	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Greeshma	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Varsha	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Sharad	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Hemant	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Shishir	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			

b) Source-Tube well Vessel - *Tamra*

Rutu	Time		0 Hr		d.f.	McNemar chi-square (corrected)	P-value
			1	**2**			
Vasant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Greeshma	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Varsha	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Sharad	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Hemant	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			
Shishir	**12 Hr**	**1**	6	0	1	-	-
		2	0	0			
	24 Hr	**1**	6	0	1	-	-
		2	0	0			
	48 Hr	**1**	6	0	1	-	-
		2	0	0			

Source Tube well Vessel – Stainless steel

Rutu	Time		0 Hr		d.f.	McNemar chi-square (corrected)	P-value
			1	2			
Vasant	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Greeshma	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Varsha	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Sharad	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Hemant	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			
Shishir	12 Hr	1	6	0	1	-	-
		2	0	0			
	24 Hr	1	6	0	1	-	-
		2	0	0			
	48 Hr	1	6	0	1	-	-
		2	0	0			

A) Source –River Vessel – *Tamra* & Stainless steel

There was no change in *Gandha* for any sample of river irrespective of vessel (*Tamra* or stainless steel) and *rutu*.

B) Source-Tube well Vessel – *Tamra* & Stainless steel

There was no change in *Gandha* for any sample of tube well irrespective of vessel (*Tamra* or stainless steel) and *rutu*.

2) BERWEEN GROUP EFFECT

i) Colour a) Source –River

Rutu	N	Comparison	(non-zero) Median difference (tamra – stainless steel)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

b) Source –Tube well

Rutu	N	Comparison	(non-zero) Median difference (tamra – stainless steel)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

A) Source –River

For river sample, in *Varsha rutu* & *Geeeshma rutu* equal or same results are found for both *Tamra* and Stainless steel vessel at every time interval. For all other *rutus* colour remained unchanged for both *Tamra* and Stainless steel vessel.

B) Source –Tube well

For tube well sample, in *Varsha rutu* equal or same results are found for both *Tamra* and Stainless steel vessel at every time interval. For all other *rutus*, colour remained unchanged for both *Tamra* and Stainless steel vessel in all *rutus*.

ii) Shuddhi

a) Source –River

Rutu	**N**	**Comparison**	**(non-zero) Median difference (tamra - stainless steel)**	**Wilcoxon signed rank test T^+**	**P-value**
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

b) Source –Tubewell

Rutu	N	Comparison	(non-zero) Median difference (tamra – stainless steel)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

A) Source –River

For river sample, in *Varsha rutu* & *Geeeshma rutu* equal or same results are found for both *Tamra* and Stainless steel vessel at every time interval. For all other *rutus Shuddhi* remained unchanged for both *Tamra* and Stainless steel vessel.

B) Source –Tube well

For tube well sample, in *Varsha rutu* equal or same results are found for both *Tamra* and Stainless steel vessel at every time interval. *Shuddhi* remained unchanged for both *Tamra* and Stainless steel vessel in all *rutus*.

iii) Shitata a) Source –River

Rutu	N	Comparison	(non-zero) Median difference (tamra – stainless steel)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

b) Source –Tube well

Rutu	N	Comparison	(non-zero) Median difference (tamra - stainless steel)	Wilcoxon signed rank test T^+	P-value
Vasant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Greeshma	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Varsha	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Sharad	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Hemant	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-
Shishir	6	0 hr – 12 hr	0	-	-
	6	0 hr – 24 hr	0	-	-
	6	0 h – 48 hr	0	-	-

A) Source –River

For river sample, In *Vasant* & *Greeshma rutu*, the improvement in *Shitata* for water stored in *Tamra* vessel & stainless steel vessel is equal or same for every time interval. For all other *rutus Shitata* remained unchanged for both *Tamra* and Stainless steel vessel.

B) Source –Tube well

For tube well sample, *Shitata* remained unchanged for both *Tamra* and Stainless steel vessel in all *rutus*.

iv) Odour

a) Source –River

Rutu	**Vessel**	**48Hr**		**d.f.**	**chi-square (corrected)**	**P-value**
		1	**2**			
Vasant	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Greeshma	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Varsha	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Sharad	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Hemant	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Shishir	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			

b) Source –Tube well

Rutu	**Vessel**	**48Hr**		**d.f.**	**chi-square (corrected)**	**P-value**
		1	**2**			
Vasant	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Greeshma	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Varsha	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Sharad	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Hemant	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Shishir	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			

v) *Gandha*

a) Source –River

Rutu	**Vessel**	**48Hr**		**d.f.**	**McNemar chi-square (corrected)**	**P-value**
		1	**2**			
Vasant	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Greeshma	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Varsha	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Sharad	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Hemant	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Shishir	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			

b) Source –Tube well

Rutu	**Vessel**	**48Hr**		**d.f.**	**McNemar chi-square (corrected)**	**P-value**
		1	**2**			
Vasant	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Greeshma	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Varsha	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Sharad	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Hemant	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			
Shishir	*Tamra*	6	0	1	-	-
	Stainless steel	0	0			

A) Source –River

There was no change in Odour & *Gandha* in river water for any *rutu* and any time interval.

B) Source –Tube well

There was no change in Odour & *Gandha* in tube well water for any *rutu* and any time interval.

SUBJECTIVE PARAMETR OVERALL ASSESSMENT - SOURCE WISE

1) WITHIN GROUP EFFECT

A) Source –River Vessel - *Tamra*

For river samples, the improvement in parameters Colour, S*huddhi* and *Shitata* for water stored in *tamra* vessel was significant at time intervals - Raw-12 Hr, Raw – 24 Hr and Raw – 48 Hr. (all P-values < 0.05) as suggested by Wilcoxon signed rank test .

For river water, there was no change observed for parameters *Gandha* and Odour for water stored in *tamra* vessel.

Source –River Vessel: Stainless steel

For river samples, the improvement in parameters Colour, S*huddhi* and *Shitata* for water stored in stainless steel vessel was significant at time intervals - Raw-12 Hr, Raw – 24 Hr and Raw – 48 Hr. (all P-values < 0.05) as suggested by Wilcoxon signed rank test .

For river water, there was no change observed for parameters *Gandha* and Odour for water stored in stainless steel vessel.

B) Source –Tube well Vessel - *Tamra*

For tube well water, there was no change observed for parameters Colour, S*huddhi* and *Shitata* for water stored in *tamra* vessel.

For tube well water, there was no change observed for parameters *Gandha* and Odour for water stored in *tamra* vessel.

Source –Tube well Vessel: Stainless steel

For tube well water, there was no change observed for parameters C*olour, Shuddhi and Shitata* for water stored in stainless steel vessel.

For tube well water, there was no change observed for parameters *Gandha* and Odour for water stored in stainless steel vessel.

2) BETWEEN GROUP EFFECT

A) Source –River

For river sample, the improvement in parameter Colour was not significantly higher for water stored in *tamra* vessel than that stored in stainless steel vessel for time interval 0 Hr – 12 Hr (P-value = 0.149) while for time intervals 0 Hr – 24 Hr and 0 Hr – 48 Hr the improvement in Colour observed with *tamra* vessel was significantly higher than that observed for stainless steel vessel (P-values = 0.037 & 0.037 respectively).

For river sample, the improvement in parameter *Shuddhi* was not significantly higher for water stored in *tamra* vessel than that stored in stainless steel vessel for time interval 0 Hr – 12 Hr (P-value = 0.149) while for time intervals 0 Hr – 24 Hr and 0 Hr – 48 Hr the improvement in *Shuddhi* observed with *tamra* vessel was significantly higher than that observed for stainless steel vessel (P-values = 0.037 & 0.037 respectively).

For river sample, the improvement in parameter *Shitata* was significantly higher for water stored in *tamra* vessel than that stored in stainless steel vessel for time interval 0 Hr – 12 Hr (P-value = 0.020) while for time intervals 0 Hr – 24 Hr and 0 Hr – 48 Hr the improvement in *Shitata* observed with *tamra* vessel and stainless steel vessel were same.

For river sample, the improvement in parameters – Odour and *Gandha* for water stored in *tamra* vessel and water stored in stainless steel vessel were exactly same.

B) Source –Tube well

For tube well sample, the improvements in parameter *Colour*, *Shuddhi* and *Shitata* for water stored in *tamra* vessel and that stored in stainless steel vessel were all the same for all time intervals.

For tube well sample, the improvement in parameters – Odour and *Gandha* for water stored in *tamra* vessel and water stored in stainless steel vessel were exactly same.

SUBJECTIVE PARAMETER GRADATION

Ayurvedic Subjective Parameters –

1) ***Gandha*** – Smell of the water feel by nose

Gradation – ***Sgandha* - 2**
***Nirgandha* – 1**

Sgandha – Muddy, fleshy smell feel by nose
Nirgandha – No any smell feel by nose

2) ***Shuddhi*** – Clarity of water i.e. Varna of the drinking water seen by naked eyes

Gradation – ***Heen Shudhi* - 3**
***Madhyam Shudhi* - 2**
***Pravar Shudhi* – 1**

Heen Shudhi – Dark coloured or total muddy water seen by naked eyes i.e. total Turbid water identify by visualization.
Madhyam Shudhi – Slightly coloured water or slightly muddy water i.e. Turbidity identify by visualization.
Pravar Shudhi – Clear water i.e. no any colour or muddiness or dirty appearance to the water or no Turbidity will be identify by visualization

3) ***Shitata*** – Temperature sensed by the finger after dipping in water

Gradation – ***Alpakoshna* - 3**
***Shita* -2**
***Atishita* – 1**

Alpakoshna jal - Water sensed slightly hot by the finger dipping
Shita jal – Water sensed cold by the finger dipping
Atishita jal – Water sensed very cold by the finger dipping

Modern Subjective Parameters –

1) Colour – Colour of water means seen by naked eyes

Gradation – **Brownish or muddy - 3**
Mild yellowish or slight muddy - 2
Colourless – 1

Brownish or muddy – Dark coloured or total muddy water seen by naked eyes i.e. Total Turbid water identify by visualization

Mild yellowish or muddy – Slightly coloured water or slight muddy water i.e. Turbidity identify by visualization

Colourless – Clear water i.e. no any colour or muddiness or dirty appearance to the water or no Turbidity will be identify by visualization

2) Odour – Smell of the water feel by nose

Gradation – **Objectionable Odour - 2**
Unobjectionable / Odourless – 1

Objectionable odour – Muddy, fishy smell feel by nose

Unobjectionable – No any smell feel by nose

ADDITIONAL WORK DONE OTHER THAN MENTIONED IN PROTOCOL

1) SAMPLE OF PURIFIED WATER FROM GRAMPANCHAYAT – OBSERVATIONS & RESULTS

Additional testing of one sample from Grampanchyat purified water was taken to assess its further improvement in various parameters according to vessel used to store water i.e. *Tamra* and Stainless steel .

Parameters	Raw	*Tamra* Vessel			Stainless Steel		
		12hr	24hr	48hr	12hr	24hr	48hr
Turbidity	2.1	1.9	1.9	1.9	1.9	1.9	1.9
Temp	27	26	27	27	27	27	27
Hardness	158	156	154	150	157	155	154
pH	6.8	7	7.1	7.2	7	7	7
TSS	11	10.6	10.2	10.2	10.9	10.7	10.6
TDS	290	286	282	280	287	284	281
MPN	24	2	0	0	21	20	20

Though this study was taken with only single sample statistical analysis is not possible.

Observations & results shows that –

Turbidity of water stored in *Tamra* vessel showed reduction of 0.2 while the turbidity of water stored in Stainless steel vessel reduced by 0.2.

Water stored in *Tamra* vessel showed reduction of $1^{O}C$ in temperature for time interval raw - 12hr while for subsequent time intervals, raw – 24hr & raw - 48 hr there was no reduction in temperature. Also there was no reduction in temperature for water stored in Stainless steel vessel at every time interval, temperature remains as it is.

Hardness was reduced by 2, 2 & 4 mg. for water stored in *Tamra* vessel while for water stored in Stainless steel vessel, hardness reduced by 1, 3 & 4 mg. at the time interval 12hr,24hr & 48hr respectively.

pH was increased by 0.2,0.3 & 0.4 for water stored in *Tamra* vessel at the time interval 12hr,24hr & 48hr respectively. While for water stored in stainless steel vessel, raised by 0.2 for time interval 12hr & 48 hr pH remained unchanged.

TSS reduced by 0.4, 0.8 & 0.8 mg. for water stored in *Tamra* vessel while for water stored in stainless steel vessel, hardness reduced by 0.1,0.3 & 0.4 mg. at the time interval 12hr,24hr & 48hr respectively.

TDS reduced by 4, 8 & 10 mg. for water stored in *Tamra* vessel while for water stored in stainless steel vessel, hardness reduced by 3, 6, & 9 mg. at the time interval 12hr, 24hr & 48hr respectively.

Water stored in *Tamra* vessel showed reduction of 22 in MPN for time interval raw - 12hr while for subsequent time intervals, raw – 24hr & raw - 48 hr there was total reduction in MPN. For water stored in Stainless steel vessel reduction in MPN for time interval raw - 12hr is 3 while by 4 at each time intervals, raw – 24hr & Raw - 48 hr

2) ADDITIONAL ANALYSIS OF COPPER IN WATER & MALACHITE OF *TAMRA* VESSEL

OBSERVATIONS & RESULTS

Additional analysis of release of copper ion in water & quantity of copper in malachite (basic copper carbonate) was done. Observations are as follows -

Time Duration	**Copper ion in mg/lit**	
	River Water	Tube well Water
12 hrs	0.188	0.571
24 hrs	0.189	0.973
48 hrs	1.121	1.082

Source of water	Quantity of Copper in Malachite (basic copper carbonate) after 48 hrs
River	2.57 mg/lit
Tube well	3.13 mg/lit

Observations show that copper ions are present in water. Concentration of copper ions increases with time duration in both sources. The data shows that quantity of copper ions is more in tube well water than river water.

Also the analysis of malachite, which was done after 48 hrs, shows presence of copper in malachite both the sources. Results show that quantity of copper in malachite is more formed by tube well water than river water.

DISCUSSION

Discussion is the most important part of research work. In discussion we discuss important points from hypothesis to results obtained from research data. It is nothing but the logical reasoning of observations.

The study was undertaken to observe the changes in qualities of water stored in *Tamra* & Stainless steel vessels. To carry out this research work the study is conducted on water samples of River & Tube Well and vessels for water storage are *Tamra* & Stainless Steel vessels. Study design for this research work is Laboratorial Experimental Study

The entire research work is discussed in following steps - Review of literature, Material & methods, Plan of work, Observations & Results with statistical analysis.

1) DISCUSSION ON REVIEW OF LITERATURE:-

Comprehensive review of literature is taken from all classical Ayurvedic texts from Vedic era to till today &from modern texts, also from electronic media along with the review of work done by others.

The whole review of literature is discussed in the sequence given in the chapter Review of literature.

I) DISCUSSION ON *JAL* OR WATER REVIEW:-

a) Discussion on sources of water & their properties –

In the *Vedas* water has been described for its medicinal properties & different types of water therapies are also mentioned. In various *Puranas* importance of water is given. In *Darshana Granthas* various *avasthas* of water are prescribed.

Sources of water are described in detail in *Vedas, Tarkasangraha* & Ayurvedic *Samhitas*. According to sources in Ayurvedic *Samhita* water is mainly divided into two major types one is

Divya & second is *Bhauma* . *Bhauma* is again divided into 8 types which includes surface & grounds water. From these types of water *Divya Jala* is a pure form of water.

Ancient practice of collecting rain water and using it for drinking is harmful to health, now a days. In olden days rain water was pure and so good for health, but not so now a day. With the increasing industrialization the atmosphere has become polluted with poisonous gases, fumes and dust so the rain water coming down from the clouds gets polluted to a great extent, because of this only we experience the sour rain, salty rain, crimson rain etc. frequently. Use of such polluted rain water for drinking is not good for health.

Modern science also describes three types of water sources rain water, surface water& ground water. Among these rain water is prime & purest source in nature, but ground water is most usable source by population as compare to surface water. Also it is the cheapest, superior according to pathogens & most practical means of providing water to small communities than surface water. Ground water is much hard than surface water. Theory behind this is when any water comes in contact with the atmosphere it absorbs CO_2 & as these water (H_2O) come into contact with rocks & sediments they acquired metal ions commonly Ca & Mg .So most natural water that comes from stream, lacks & especially wells, tub wells can be regarded as dilute solution of these bicarbonates.

Ayurveda stated that the properties of the falling rain water depend upon the *Desha, Kaal & Mahabhuta* (geological part , season & predominance of *mahabhuta*)

According to seasons; and according to the celestial positions of sun & moon and different constellations in the sky, the falling rain water possesses different qualities and properties. The falling rain water shall also be transformed into a different types according to the mixing of the atmospheric dust, the suspended and floating bacteria (*jantu*),etc.

When actually the rain water hits the earth surface, the properties of the earthen surface also imparts its properties to the falling rain water such as the temperature of the earth surface. The earthen surface may be extremely cold or extremely hot and the water accordingly will acquire that cold or hot temperature.

It is our common experience that the first rains will hit the hot earthen surface and will produce a kind of aroma which is very pleasant and exciting. On the other hand the rain falling in cold season is not welcome and it is difficult to digest. Like the temperature the fallen rain water also acquire other properties like oiliness and there is a *Gunaantar* to either become good water or bad and dirty water.

Acharyas described properties of rain water fallen on various types of soil or geographical condition in detailed which are not mentioned in modern medicine in a such way. Water from *Sadharana Desha* & *Jangla Desha* (water from desert like regions) is good for use or digestible but water from *Anupa Desha* (water from marshy regions) is not suitable for health. The digestibility of water is dependent on its source being located near desert, swamp or mountain regions . If the reservoir of water is in arid or desert region the water from that source is easily digestible, if the source is near mountains it is still more easily digestible, if the source is near swamps which are water logged always the water will be hard to digest

Digestibility was the criteria to decide the potability of water in ancient times in contrast to the present day criteria of hardness or softness .Soft water is easily digestible while hard water is hard to digest.

b) Discussion on *Kalaganana* & properties of *jala*, according to *Shadrutu* (season)

The whole year is divided into two semesters which are *Uttarayana* (northern solstice) & *Dakshinayana* (southern solstice).This nature of two semesters described above are quite opposite of one another. The *Uttarayana* (northern solstice) is hot because during this period the movement of sun will be little more towards the north on its elliptical path & so earth comes a little nearer to it and therefore heat of sun is severe which takes away the moisture of the earth . Exactly opposite to this is *Dakshinayana* (southern solstice) which is colder because during this period the movement of sun will be slightly towards the south on its elliptical path, earth moves a little away from the sun and therefore heat of sun reduces , the moisture on the earth increases.

In all above described six seasons due to position of sun and earth climate becomes different which results into environmental changes i.e. air , water , moisture of plant takes place as well as changes take place inside the body of human being because of this *Ayurveda* described specific regimen for every *Rutu.*

Water properties are also not permanent and constant. They change from place to place and season to season. *Acharyas* described changes in qualities of water according to *Rutu* (season) in detailed and also given advice of what type of water should be taken in specific season also what type of treatment is required in every seasons.

Both Ayurveda & modern science the characteristics of good potable water as well as bad or unhygienic water are given in detail.

c) Discussion on *Jala Shodhana* (Purification of water)

Acharyas given various methods of purification or treatment of water. It is mentioned under the chapter "*Jala Shodhana*". According to Ayurveda one should drink water which is cold, pure, wholesome, palatable, clean and light. The characteristic and properties of good potable water change according to seasons. So there is a need of purification or treatment of water which is contaminated. In ancient times methods of purification of water were - a) filtration through thick cloth b) boiling c) making it clear with addition of some herbs and d) removing its bad smell by putting into it some fragrant flowers. These are only limited up to small scale water purification or house hold water purification.

In *Charaka Samhita* there is no reference about *Jala Shodhana* i.e. purification of water. He has described only properties of Jala in detail. But in *Sushruta Samhita , Ashtanga Sangraha* & *Bhavaprakash* methods of *Jala Shodhana* are described. Comparing above texts *Sushruta* has given specifications of these methods in detail. ***Sushruta*** mentioned following methods of ***Jala Shodhana*** **-** Boiling, *Nirvapana*, Removing of bad smell, Storage, *Prasadana*, Filtration & *Shitikarana.*

Under modern medicine various water purification methods are given and in addition to Ayurveda they have mentioned both large scale as well as small scale water purification methods in detail. For large scale purification of water they have mentioned three steps i. e. Storage, Filtration & Disinfection. For disinfection they have suggested Chlorination at both large scale & small scale purification of water. Chlorination is the best procedure which makes water potable & free from microorganisms.

II) DISCUSSION ON STORAGE OF WATER IN VARIOUS METAL VESSELS:–

For present study we are concentrating only on the method of storage of water in various vessels and especially in copper vessel. Under this *Sushruta* suggested total six pots or vessels of gold, silver, copper, bronze, precious stone or in earthen pots which were used at that time by people .These pots are in daily practice for cooking , storage & serving by population in that era. According to economical status people were using these pots in their kitchen. From these gold, silver, copper, bronze are heavy metals, because of this after storing water in these vessel , the metal ions releases in water and contact of these metal ions & water results purification of water. That is the reason the micro-organisms get killed in such water, this is called the Oligodynamic effect. The oligodynamic effect is a toxic effect of metal-ions on living cells, algae, moulds, spores, fungi, virus, prokaryotic and eukaryotic microorganisms, even in relatively low concentrations. This antimicrobial effect is shown by ions of mercury, silver, copper, iron, lead, zinc, bismuth, gold, aluminum and other metals. These anti-microbial properties can inhibit growth of harmful bacteria. This Oligodynamic effect of heavy metals is mentioned in modern literature.

It is important to note that during the regime of *Samhitas* , experts of Ayurveda and public were adequately aware of the water pollution and the water born diseases without a detailed knowledge of existence of pathogenic, enteric bacteria and organisms. At this era of *Samhitas*, some five thousand years ago environmental, water and air pollution was almost nil. Whatever water pollution was there, it was taken good care of by using the herbal water purifying agents like *Katak beej , Bisa granti* (rhizome of lotus) , *Saivala mula* (root of algae) etc.

Ancient methods of purification of water were having limited scope both in respect of quality of water and removal of contaminants physical, chemical & biological.

III) DISCUSSION ON *TAMRA* OR COPPER REVIEW:-

Ayurveda experts were well enough aware about these heavy metals like gold, silver, copper etc. & their properties as well as the chemistry of these metals. They have given information about these metals and their uses in medicine and also for domestic purpose. References are available from *vedic* as well as *samhita* period but in *Rasashastra* it is described in detailed.

From ancient time copper is used by people in the form of coins, household utensils and vessels are also used in combination with other metal in alloys. Ayurveda has already attributed several medicinal uses for Copper chiefly based on its anti-bacterial properties. Storing water in copper vessels, for instance, is known to kill harmful bacteria and prevent premature aging

According to modern science Copper is one of the oldest metals known to civilization. It is the one of the heavy metal. They have mentioned physical chemical properties of these metals as well as their actions with environmental materials & with other in detail with scientific reasons. Modern science recognizes oligodynamic effect of heavy metals with water to kill harmful bacteria.

2) DISCUSSION ON MATERIALS AND METHODS: -

This is the Laboratorical Experimental Study in which assessment of water qualities stored in *Tamra* & Stainless steel vessels is examined. The Study is conducted on water samples of River & Tube Well only. *Tamra* & Stainless Steel vessels with lid having capacity of 5 liter water storage are taken for this study.

For the present study only one vessel is taken into consideration from the reference of *Sushruta* & that is *tamra* (copper) vessel because most probably these vessels are readily available in rural areas since generations and are comparatively affordable than other metal vessels mentioned in *shloka*. As this is comparative experimental study other vessel taken for study is stainless steel, which is most commonly in practice by community all over in India in urban as well as rural area.

Also for this study River & tube well these two sources are taken because according to Gazetteer Department of Maharashtra - Directory of Villages- Directory 8 - Drinking Water Facilities these are the most usable drinking water sources in Kodoli area.

I) Vessels: *Tamra* Vessel – 5 liter capacity.

Stainless Steel vessel- 5 liter capacity.

Both the vessels having water pot (*kalashi*) shaped , having same volume with lid are taken.

II) Water Sources: River &Tube Well form Kodoli area.

III) Parameter for assessment are divided into two group:-

i) Subjective Parameters - *Gandha , Shitata / Ushnata , Shudhi (avilata)* Colour & Odour

ii) Objective Parameters -

a) Physical parameters - Turbidity & Temperature

b) Chemical Parameters - Hardness, pH, Total Suspended Solids & Total Dissolved Solids

c) Microbiological - Bacteriological indicator (MPN)

Raw water collection is done in climax period of each *rutu*. Total 6 samples are taken in each *rutu* from both the sources.

Total No. of Testings are:-

i) Raw water – 2 X 6 X 6 = 72

ii) *Tamra* Vessel storage – 2 X 6 X 6 X 3 = 216

iii) Stainless Steel Vessel storage – 2 X 6 X 6 X 3 = 216

Additional testing of one sample is done other than mentioned in Protocol. This is done with Purified water supplied by Grampanchayat in research area.

Also additional analysis of release of copper ion in water & quantity of copper in malachite (basic copper carbonate) was done for *Tamra* vessel.

Assessment of water qualities of samples are done by comparison between water analysis Laboratorial results from both vessels as well as comparison with Indian Standard Specification for drinking water.

3) DISCUSSION ON OBSERVATIONS –

Observations revealed that *rutu* or season affect on qualities of raw water in every parameter in this study.

I) DISCUSSION ON OBJECTIVE PARAMETERS:-

a) Discussion on baseline comparison of various parameters of raw water of river with *rutus* -

Turbidity, Hardness, TSS, TDS & MPN of raw water of river are higher in *Varsha rutu* & less in *Sharad rutu.*

pH of raw water of river is higher in *Greeshama rutu* & less in *Varsha rutu* .

While Temperature of raw water of river is higher in *Greeshma rutu* & less in *Hemant rutu.*

b) Discussion on baseline comparison of various parameters of raw water of tube well with rutus

Turbidity, Hardness & TDS for tube well raw water is higher in *Greeshma rutu* & less in *Sharad rutu.*

Temperature for tube well raw water is higher in *Greeshma rutu* & less in *Hemant rutu.*

pH for tube well raw water is higher in *Greeshama rutu* & less in *Varsha rutu.*

TSS & MPN for tube well raw water is higher in *Varsha rutu* & less in *Sharad rutu.*

Turbidity –

Turbidity is found low during the winter season and high in rainy season. It might be due to the high silt content of the water carried down into the river by the feeder streams from the catchment areas. According to Khan and Chowdhury (1994) high value of turbidity during rainy seasons may be due to heavy load of silt into the river water from the feeder streams.

Temperature –

Temperature found higher in summer due to low water level, high temperature of environment & clear atmosphere and relatively lower in winter due to reverse conditions.

pH –

pH is found higher in *Greeshama rutu* due to low water level which increases bicarbonate concentration of water & less in *Varsha rutu* which relevant to Ayurvedic literature i.e. in *Varsha rutu* water gets *amlavipaki* & it is because of cloudy climate, poor sunrays & accumulation of impurities in sources.

Hardness & Total dissolved solids –

TDS is a measure of inorganic and organic materials dissolved in water. High TDS level indicates water hardness in respective sampling station.

For river raw water - Hardness & Total dissolved solids had a cyclic pattern of seasonal changes and maximum during rainy season and minimum in winter. This indicated that the dissolved materials were of allochthonous origin, which was brought into the river system with surface runoff. Level of carbonate is found higher during early monsoon.

For tube well raw water - Hardness & TDS is higher in *Greeshma rutu* & found less in *Sharad rutu.* This is because that decreases in water volume causes increase in bicarbonate concentration.

MPN & Total Suspended solids –

The data indicates that quality of water in *varsha rutu* is unsatisfactory and is much polluted. Comparing the quality of water in all seasons, water in *Sharad rutu* is better in quality than any other rutu . Both the observations are relevant to Ayurvedic literature.

River water is one of the sources of surface water & surface water derives its impurities from surface washings, sewage and sludge water, industrial and trade waters and drainage from agricultural areas. The customs and habits of the people like bathing, animal washing and disposal of the dead, all adds to the pollution of water. During rainy season all these impurities

comes in maximum number through rain water because of this in *Varsha rutu* rivers are more polluted.

According to Ayurveda *Sharad Rutu* comes in the months *Shravana* & *Bhadrapada* i. e. 15 August to 15 Oct. In the month of *Bhadrapada* sun is perpendicular to earth and is nearest to earth than other *rutu* , sky is very clear no clouds so rays become very intense / extreme in day hours. Due to these powerful UV rays the disinfection of water takes place as well as *Agastya* is the name of star (canopus) which appears in the sky on the seventh day of second half of the month of *Bhadrapada* (mid September) and continues to shin for about two months . Hindu astronomy states that its rays have the effect of detoxicating poisons and so water kept exposed at nights during this period is equal to nectar. Due to this water in *Sharad rutu* is better in quality than any other *rutu*.

c) Discussion on baseline comparison of various parameters of raw water of river with Tube well -

Turbidity comparison data shows that river water is more turbid than tube well water in every *rutu*. Also the MPN count is higher in river water than that of tube well water in each *rutu*.

Observations revealed that TSS of river water is higher than that of tube well in every *rutu*. This occurs due to all dissolved and suspended impurities mixed with the surface water sources & get polluted.

The data indicate that Hardness & TDS of tube well water is elevated than that of river water. These observations are relevant to literature study.

When water comes in contact with the atmosphere it absorbs CO_2 & as H_2O comes into contact with rocks & sediments it acquires metal ions commonly Ca & Mg. So most natural water that comes from streams, wells & tube wells can be regarded as dilute solutions of these bicarbonates.

d) Discussion on baseline comparison of various parameters of raw water of river & tube well with WHO & Indian Standard Specification for drinking water -

Comparing this data of raw water of River with WHO & Indian Standard Specification for drinking water, the parameter Turbidity, pH, TSS & TDS shows that these are in desirable

limits and Hardness shows at borderline limits but MPN is exceeding the limit so it is undesirable and needs treatment before using it for drinking.

While considering raw water of tube well it shows that parameter turbidity, pH, TSS &TDS are in desirable limits according to WHO & Indian Standard Specification for drinking water but Hardness & MPN are at exceeding the limit so it is undesirable and needs treatment before using it for drinking.

Observations revealed that the overall quality of raw water at various collection places of river as well as tube well is found to be unsatisfactory throughout all *rutus*, therefore one cannot drink this water without purification.

II) DISCUSSION ON SUBJECTIVE PARAMETERS:-

a) Discussion on baseline comparison of various parameters of raw water of river with *rutus*

Colour & *Shuddhi* score of river raw water is higher in *Varsha rutu*

While score of *Shitata* is higher in *Vasant* & *Greeshma rutu*

There is no change in Odour & *Gandha* for any sample of river raw water irrespective of *rutu.*

b) Discussion on baseline comparison of various parameters of raw water of tube well with *rutus*

Colour & *Shuddhi* score of tube well raw water is higher in *Varsha rutu*

There is no change in *Shitata*, Odour & *Gandha* for any sample of raw water of tube well irrespective of *rutu.*

c) Discussion on baseline comparison of various parameters of river water with tube well

In *Varsha* & *Greeshma rutu* score of Colour & *Shuddhi* of river raw water is higher than tube well raw water and for other *rutu* score of Colour & *Shuddhi* is identical for both sources.

In *Vasant* & *Greeshma rutu* score of *Shitata* of raw water of river is higher than that of tube well water and for other *rutu* score of *Shitata* is identical for both sources. Scores of Odour & *Gandha* are identical for water of both the sources i.e River & tube well.

4) DISCUSSION ON RESULTS –

In present study raw water of river as well as tube well are stored in copper & stainless steel vessel for the time duration 48hrs totally. Assessment was done comparing the data before storing it in vessel with after 12hr , 24hr & 48hr storage i.e. raw to 12hrs, raw to 24hrs & raw to 48hrs of each sample for various parameters. The result showed very good effect of water stored in copper vessel as compared to stainless steel vessel. Reduction in MPN is found highly significant in water stored in copper vessels than that of stainless steel which is the important parameter for quality of water.

I) Discussion on Results of Objective Parameters:-

Comparing all observations with results we found that for parameter Turbidity, Hardness, TSS, TDS& MPN there is reduction in their figures / values in every season. For temperature reductions as well as rise has taken place. After 12hr of storage in both the vessels temperature goes down to some extent & after further storage of 24 & 48 hrs. rise in temperature takes place in hot season while reduction takes place in cold season according to changes in temperature of environment. For pH there is slight rise in figures / values in every season.

1) Turbidity –

We observed significant reduction in turbidity in *Vasant, Greeshma, Varsha, , Hemant and Shishir rutu* for both vessels for river water as well as for tube well water. For *Sharad rutu* reduction is up to certain limit in both the vessels.

Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds, planktons and other microscopic constituents. Storage for hours settles the impurities in it by gravitational force.

For river as well as tube well source, in each *rutu*, reduction in turbidity for water stored in *Tamra* vessel and Stainless steel vessel is not significantly different.

So there is no any influence of vessel regarding turbidity.

2) Temperature –

Temperature shows reduction as well as increase for both vessels identically and which is respective to temperature variations in atmosphere.

So there is no any influence of vessel regarding temperature.

3) Hardness –

We observed significant reduction in Hardness in all rutus for both vessels for river water as well as for tube well water.

For river water reduction in hardness is more effective in *Tamra* vessel than stain less steel vessel.

For tube well water reduction in hardness is more effective in Tamra vessel than stain less steel vessel.

Cu++ ions which are released by copper vessels reacts with dissolved O2 to form soluble CuO(Copper Oxide). Which further reacts with bicarbonates present in water to form Malachite/ Basic copper carbonate (Cu2(OH2)Co3) which is turquoise to green colour. Thus when water is stored in copper vessel for long duration we found green colour layer of malachite inside the copper vessel.

Removal of bicarbonates from water results in reduction in hardnees caused by bicarbonates.

4) **pH-**

We observed slight increase in pH in all *rutu* for both the vessels for river water as well as for tubewell water.

So there is no any influence of vessel regarding pH.

5) Total Suspended Solids (TSS)-

We observed significant reduction in TSS in all *rutu* for both vessels for river water as well as for tube well water.

Storage for hours settles the suspended matter in it by gravitational force.

For river as well as tube well source, reduction in TSS for water stored in *Tamra* vessel and Stainless steel vessel is not significantly different in every *rutu*.

So there is no any influence of vessel regarding TSS.

6) Total Dissolved Solids (TDS) -

We observed significant reduction in TDS in all rutus for both vessels for river water as well as for tube well water.

For river water reduction in TDS is more effective in *Tamra* vessel than stain less steel vessel.

For tube well water reduction in TDS is more effective in *Tamra* vessel than stain less steel vessel.

Hardness reduction results in TDS reduction as these bicarbonates are in dissolved form which are removed by Cu++

7) Most Probable Number (MPN)-

We observed significant reduction in MPN in all *rutus* for both vessels for river water as well as for tube well water.

For River samples, storage of water in *Tamra* vessel is remarkably effective in reduction of MPN than Stainless steel vessel in each *rutu* at every time interval.

For tube well samples, also storage of water in *Tamra* vessel is remarkably effective in reduction of MPN than Stainless steel vessel in each *rutu* at every time interval.

From these results we can say that both metals have disinfecting ability but *Tamra* vessel shows highest anti microbial activity.

When water is stored in a copper vessel, in very small quantities cooper gets dissolved in water. This is known as the oligodynamic effect. The oligodynamic effect was discovered in 1893 by the Swiss KW Nageli. This has the power to destroy a wide range of molds, fungi, algae and harmful microbes due to its toxic effects on living cells. This antimicrobial effect is shown by ions of: mercury, silver, copper, iron, lead, zinc, bismuth, gold, aluminum and other metals.

When copper dissolves in water, water becomes ionic (electrolyte) . The production of copper ions kills the algae and bacteria. Electrically charged copper ions ($Cu^{+}2$) in the water search for particles of opposite polarity, such as bacteria, viruses and fungi. Positively charged copper ions form electrostatic compounds with negatively charged cell walls of microorganisms. These compounds disturb cell wall permeability and cause nutrient uptake to fail. The copper ions have the ability to pierce the protective outer membrane of a cell and disrupt the enzyme balance thereby killing microbes. (Int.J.Curr.Microbiol.App.Sci (2013) 2(11): 24-29)

A copper ion distorts the cell wall of microorganisms by binding to negatively charged groups.(Hambidge 2001) Copper has antimicrobial property and this can inhibit growth of harmful bacteria. So *tamra* vessel is good choice for storage of water than stainless steel.

I have already mentioned that additional testing of one sample is done with Purified water supplied by Grampanchayat in research area which are extra efforts other than protocol. Comparing data of this water sample with WHO & Indian Standard Specification for drinking water, the parameter turbidity, Temperature, pH, Hardness, TSS & TDS shows that these are in desirable limits but MPN is exceeding limit so it is undesirable. Observations show that purified water supplied by Grampanchayat at kodoli contain MPN in objectionable amount so there is question about its purity, may be contamination during supply & requires household treatment before using it for drinking.

Results of this single sample show that for the parameter Turbidity, Temperature, pH, Hardness, TSS & TDS are identical for both vessels. While for MPN water stored in *Tamra* vessel have remarkable reduction than Stainless steel vessel at every time interval. After 24hr MPN /100ml shows nil for water stored in *Tamra* vessel.

Additional analysis of release of copper ion in water & quantity of copper in malachite (basic copper carbonate) was done for *Tamra* vessel. Observations show that presence of copper ion in water and also the presence of copper in malachite for the both sources. Tube well water as well as malachite formed by tube well water shows higher concentration of copper than river water.

This difference of copper concentration in two water sources may be due to excess presence of bicarbonates in tube well water which may influence to release excess copper ions from copper vessel.

II) Discussion on Results of Subjective Parameters:-

1) Colour –

For river water improvement in colour is effective in both vessels for *Varsha* & *Greeshma rutu* .Though the improvement is identical the difference in improvement in colour of water stored in *Tamra* & Stainless Steel for every time interval is insignificant .For other *rutu* colour remained unchanged.

For tube well water improvement in colour is effective in both vessels for *Varsha rutu.* Though the improvement is identical the difference in improvement in colour of water stored in *Tamra* & Stainless Steel for every time interval is insignificant .For other *rutu* colour remained unchanged.

2) Shuddhi -

For river water improvement in *Shuddhi* is effective in both vessels for *Varsha* & *Greeshma rutu* .Though the improvement is identical the difference in improvement in *Shuddhi* of water stored in *Tamra* & Stainless Steel for every time interval is insignificant .For other *rutu Shuddhi* remained unchanged.

For tube well water improvement in *Shuddhi* is effective in both vessels for *Varsh rutu*. Though the improvement is identical the difference in improvement in *Shuddhi* of water stored in *Tamra* & Stainless Steel for every time interval is insignificant .For other *rutu Shuddhi* remained unchanged.

3) Shitata -

For river water improvement in *Shitata* is effective in both vessels for *Vasant* & *Greeshma rutu* .Though the improvement is identical the difference in improvement in *Shitata* of water stored in *Tamra* & Stainless Steel for every time interval is insignificant .For other *rutu Shitata* remained unchanged.

For tube well water *Shitata* remained unchanged for water stored in Tamra & Stainless Steel in all *rutus.*

4) & **5) Odour & Gandha –**

There is no change in Odour & *Gandha* for any sample of either river or tube well water and irrespective of vessel (*Tamra* or stainless steel) and *rutu*.

For all the above subjective parameters there is no any influence of vessel seen.

III) Discussion on Ideal time duration for storage of water-

The ideal time duration of storage is the duration at which the quality parameters of water stored in vessels are identical with that of Indian Standard Specifications. MPN is the very important parameter among above quality parameters. For river & tube well water after storage in *tamra* vessel there is remarkable reduction in MPN from 12hr storage and found the count decreasing with the passage of time. However, even after storage of water for 48 hrs. MPN was still found and hence even the storage time of 48 hrs. is not sufficient.

Grampanchayat purified water testing after 24hr storage, MPN was found zero. But this is single sample study. This data collected may not be sufficient enough to express definite conclusion about the ideal time duration for storage of water in above vessels to improve the qualities of water.

Considering the sequence of *shloka* given by *Sushruta* in chapter "*Jala Shodhana*" we observed that in first *shloka* there is description of methods of purification (*Shodhana*) & that are Boiling, *Nirvapana* & methods for Removal of Bad Smell. After this in second *shloka* he has given methods of storage of water in various vessels.Hence it is felt that probably *Sushrut* wanted to suggest that purified water (by methods given in first *shloka*) may be stored in the above metal vessels.

In present study after storage of raw water of river & tube well in copper & stainless steel vessels what changes takes place in quality of water are observed. Results of this experimental study are significant & there is improvement takes place in quality of water. When research work was in the last stage considering the above sequence of *shloka* additional testing of one sample is done with Purified water supplied by Grampanchayat in research area and results of this study are encouraging.

Water sources mostly used by people in research area are river & tube well.

For drinking purpose purified water supplied by Grampanchayat is available, in fact not daily. It is available alternate day or after every two days. The main object of this research study is to give better choice to above said population where is need of two to three days storage of water. Generally this population uses Plastic or Stainless steel pot for storage of water. Also time duration of water supply by local agency is early in the morning at 4.30 am to 5.30 am, so it is difficult to obtain for population. Because of this most of the people are using raw water sources for drinking purpose also especially tube well water.

This study is not an attempt to suggest or recommend the purification of available water on a large scale to be supplied to the community. In the present era it is not possible to advise people to purify their raw water supplies by only Ayurvedic methods because of high contamination of each and every water source. But it is an attempt to point out the promise Ayurvedic, simple and harmless storage method for household use. Current Project is concerned especially for rural population, where there is scarcity of water purification facilities in rural areas by local Govt. agencies and also if it is present, water supply may not be available daily. Because of this potable water needs to be stored for minimum 2 to 3 days. It may be a replacement to contemporary household water purifier, which are expensive & are beyond the means of each & every population especially the rural. Also current water filters requires regular maintenance & cleaning of filter candles and however this aspect is ignored by people. Moreover the treated water can get contaminated depending on storage conditions. So there is a need of easy & affordable method for water treatment & storage. At the same time this method is easy to practice and will be useful for mass population especially for rural population & can prevent epidemic diseases. Again there is no requirement of electricity or any other type of fuel for this process.

By employing this simple, effective and cheap method for storage of water at individual or family level if the individual or the locality is benefited, then the purpose of this study shall be considered as fulfilled.

LIMITATION AND SCOPE

Present study is only limited up to small scale water purification or house hold water purification and storage. It may be a replacement to contemporary household water purifier and also a good choice of simple, effective and economical method.

Considering the poor economic population cost of copper vessel may be higher as compared to stainless steel or plastic vessels which are more commonly in practice by this class of people.

There is need of appropriate cleaning of vessel before every storage of water.

Moreover further studies can be done with other vessels mentioned by *Sushruta.* Especially the clay pot which is very cheap in cost.

Also studies can be done with other sources of water given in *samhitas* well, lake, natural spring etc.

This study is limited up to only coliform bacteria. Further studies can be done with each and every microorganism which is causative factor of water born diseases.

In this project additional study was conducted with purified sample but it is a single sample study so we can't come to any conclusion. Further studies can be carried out with large no of samples for confirmation of this single sample results.

Use of copper candles in the water purifier may be tested.

SUMMARY

The current research project is conducted on Comparative study of assessment of water qualities stored in *Tamra* & Stainless steel vessels. This study is carried out with an intention to re-establish the textual facts experimentally.

The thesis has been divided into following chapters.

Aims and objectives with brief plan of work are given in introduction. The concise summary of all chapters is given below.

Review of Literature –

It deals with the valuable references about description of *jala* (water) according to Ayurvedic aspect as well as modern aspect, Review of *tamra* (copper) according to Ayurveda & modern science, Review of water stored in copper vessels. Also it includes the previous work done on water treatment by Ayurvedic methods.

Material & Methods –

It brings about details of water testing which includes method of water collection from raw sources & methods of laboratorial testing of water for each parameter. The present study was carried out on river and tubewell water stored in both *Tamra* & Stainless Steel Vessels to find out the changes in qualities in terms of physico-chemical & bacteriological parameters like colour , odour ,turbidity, temperature ,hardness, pH, TDS, TSS and MPN. Also the subjective (Ayurvedic) parameters *Gandha, Shuddhi* & *Shitata.* Six samples from different sites of each source were collected in every season (Rutu) according to Ayurveda i.e. *Varsha, Sharad, Hemant, Shishir , Vasant* & *Grishma* in order to evaluate the changes in water qualities. Collected raw water testing was done first; after that storage of water is done up to 48 hrs and observations are recorded after 12 hrs , 24 hrs & 48 hrs.

Observations & Results –

Collected data has been analyzed statistically. Paired t test, Wilcoxon signed rank test (Ordinal data), McNemar test and Pearson Chi-square test (Dichot Dichotomous data) have been used.

Discussion –

Detailed discussion regarding Review of Literature, Material & Methods, Observations & Results of this study is done under this chapter.

Changes in qualities of water in both vessels were observed and comparison was done between two vessels as well as with WHO & Indian Standard Specification for drinking water. Limitations and scope of the project are also discussed here.

Conclusion –

Improvement in qualities of water stored in *tamra* & stainless steel vessel has been included in this chapter. Results of present study are optimistic. I hope this gentle effort may open new door for further researchers on this topic.

CONCLUSION

The study entitled, "Comparative study of assessment of water qualities stored in *Tamra* & Stainless steel vessels with special reference to "*Sushrut Samhita*" was undertaken. At the end of research following conclusions can be made on the basis of observations & results obtained:-

Seasonal variations are observed in raw water quality from both the sources under study.

Raw water taken from both the sources requires sufficient treatment before drinking because it exceeds the desirable limit of MPN according to Indian standard specifications for drinking water

There are significant changes observed in qualities of water stored in *Tamra* as well as in Stainless Steel vessels respectively in every *rutu.*

Tamra Vessel seems to be more effective than Stainless Steel Vessel for improving the qualities of raw water taken from river & tube well in every *rutu.*

Tamra Vessel is more effective to reduce MPN count of raw water throughout the study period for both the sources River & Tube well in each *rutu.*

Tamra vessel has effect on parameters like Turbidity, Hardness, TSS and TDS up to certain limit.

Data collected may not be sufficient enough to express definite conclusion about the ideal time duration for storage of water in above vessels to improve the qualities of raw water from both sources.

Final conclusion would be drawn that –

Tamra Vessel may be good choice for storage of purified water for house hold purpose.

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RIVER



TUBE WELL



TAMRA VESSELS



STAINLESS STEEL VESSELS



COLLECTION OF WATER FROM RIVER



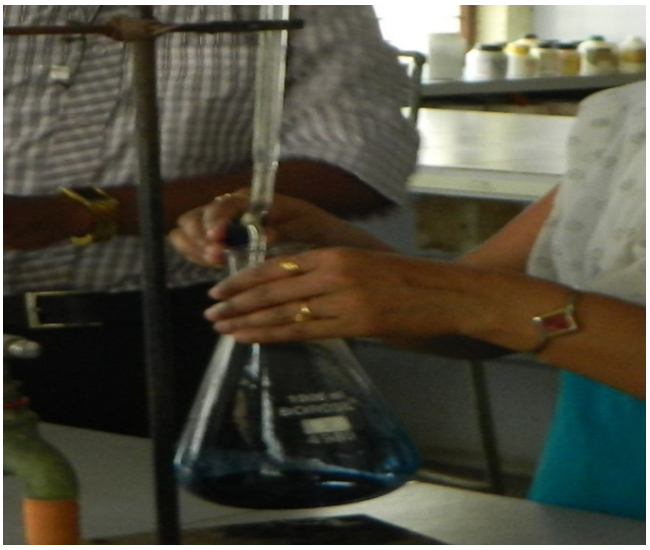
COLLECTION OF WATER FROM TUBE WELL



COLLECTED SAMPLE - FROM RIVER



COLLECTED SAMPLE -FROM TUBE WELL



HARDNESS BY – EDTA TITRATION

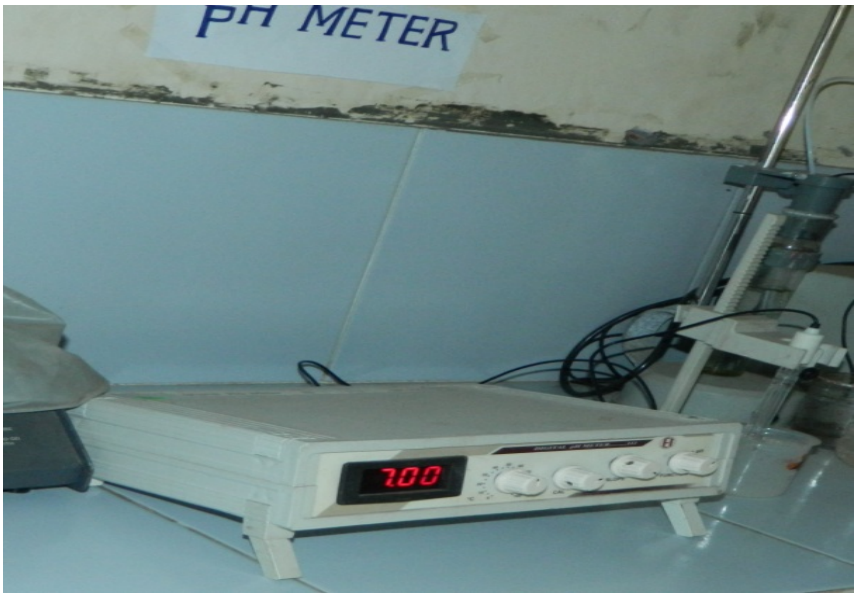


TDS BY - EVAPORATION METHOD



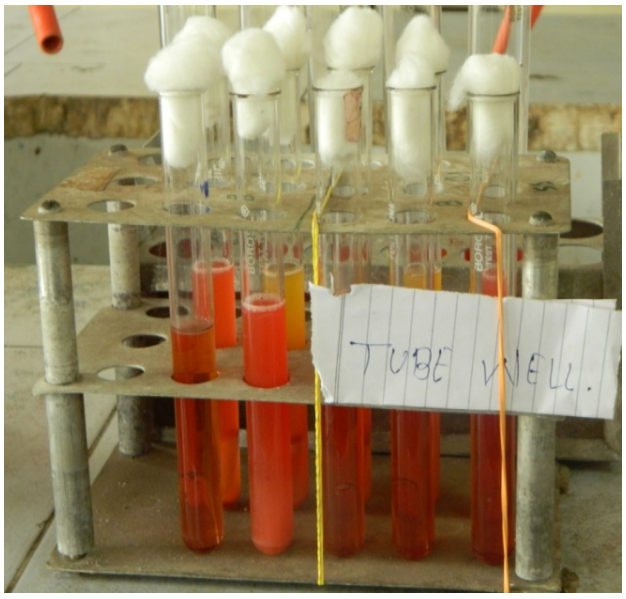


TURBIDITY BY - DIGITAL NEPHELOMETER



pH BY - pH METER





MOST PROBABLE NUMBER (MPN) - BY MULTIPLE TUBE METHOD

SHIVAJI UNIVERSITY, KOLHAPUR
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B Accredited by NAAC (2009)

Vidyanagar,
KOLHAPUR-416 004
Maharashtra, India

Ref. No./SUK/ENV

Date: 02/04/2013

Certificate

This is to certify that Dr. Kalpana K. Jadhav, Associate Professor in the Department of Swasthavritta in Yashwant Ayurvedic Post Graduate Training & Research Center, Kodoli, who is pursuing her Ph. D. (Swasthavritta) course in Tilak Maharashtra Vidyapeeth, Pune. The title of the project is **"Comparative study of assessment of water qualities stored in Tamra & Stainless steel vessels with special reference to Sushrut Samhita"** as a partial fulfillment of the curriculum of Ph. D. the scholar Dr. Kalpana K. Jadhav has been guided by Prof. P. D. Raut Department of Environmental Science, Shivaji University, Kolhapur for Water Quality Analysis and the responsibility for the results will be taken by the concerned student.

Dr. P.D. Raut
Dr. P. D. Raut
Professor and Head,
Department of Environmental Science,
Shivaji University, Kolhapur.

INDIAN STANDARD SPECIFICATIONS FOR DRINKING WATER
IS: 10500

Sr.NO	Parameter	Requirement desirable Limit	Remarks
1	Colour	5	May be extended up to 50 if toxic substances are suspected
2	Turbidity	10	May be relaxed up to 25 in the absence of alternate
3	pH	6.5 to 8.5	May be relaxed up to 9.2 in the absence
4	Total Hardness	300	May be extended up to 600
5	Calcium as Ca	75	May be extended up to 200
6	Magnesium as Mg	30	May be extended up to 100
7	Copper	0.05	May be relaxed up to 1.5
8	Iron	0.3	May be extended up to 1
9	Manganese	0.1	May be extended up to 0.5
10	Chlorides	250	May be extended up to 1000
11	Sulphates	150	May be extended up to 400
12	Nitrates	45	No relaxation
13	Fluoride	0.6 to 1.2	If the limit is below 0.6 water should be rejected Max. Limit is extended to 1.5
14	Phenols	0.001	May be relaxed up to 0.002
15	Mercury	0.001	No relaxation
16	Cadmium	0.01	No relaxation
17	Selenium	0.01	No relaxation
18	Arsenic	0.05	No relaxation
19	Cyanide	0.05	No relaxation
20	Lead	0.1	No relaxation
21	Zinc	5.0	May be extended up to 10.0
22	Anionic detergents (MBAS)	0.2	May be relaxed up to 1
23	Chromium as Cr^{+6}	0.05	No relaxation
24	Poly nuclear aromatic Hydrocarbons	----	---
25	Mineral Oil	0.01	May be relaxed up to 0.03
26	Residual free Chlorine	0.2	Applicable only when water is clorinated
27	Pesticides	Absent	----
28	Radio active	----	----

DRINKING WATER SPECIFICATION: IS: 10500, 1992 (Reaffirmed 1993)

TOLERANCE LIMITS

Sr. No	Parameter	IS: 10500 Require-ment Desirab-le limit	Undesirable effect outside the desirable limit	IS: 10500 Permissible limit in the absence of alternate source
Essential Characteristics				
1	pH	6.5 – 8.5	Beyond this range the water will effect the mucous membrane and / or water supply system	No relaxation
2	Colour (Hazen Units), Maximum	5	Above 5, consumer acceptance decreases	25
3	Odour	Unobjection able	----	----
4	Taste	Agreeable	----	----
5	Turbidity, NTU, Max	5	Above 5, consumer acceptance decreases	10
Following Results are expressed in mg/1 :				
6	Total hardness as CaCO3, Max	300	Encrustation in water supply structure and adverse effects on domestic use	600
7	Iron as Fe, Max	0.30	Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures, and promotes iron bacteria.	1.0
8	Chlorides as Cl, Max	250	Beyond this limit taste, corrosion and palatability are effected	1000
9	Residual, Free Chlorine, Min	0.20	----	---
Desirable Characteristics				
10	Dissolved solids, Max	500	Beyond this palatability decreases and may cause gastro intentional irritation	2000
11	Calcium as Ca, Max	75	Encrustation in water supply structure and adverse effects on domestic use	200
12	Magnesium as Mg,Max	30	---	100
13	Copper as Cu, Max	0.05	Astringent taste, discoloration and corrosion of pipes, fitting and utensils will be caused beyond this	1.5
14	Manganese as Mn, Max	0.1	Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply Structures	0.3
15	Sulphate as SO4 Max	200	Beyond this causes gastro intentional irritation when magnesium or sodium are present	400
16	Nitrates as	45	Beyond this methanemoglobinemia takes place	100

	NO3			
17	Fluoride, Max	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis	1.5
18	Phenolic compounds as C6H5OH, Max	0.001	Beyond this, it may cause objectionable taste and odour	0.002
19	Mercury as Hg, Max	0.001	Beyond this, the water becomes toxic	No relaxation
20	Cadmium as Cd, Max	0.01	Beyond this, the water becomes toxic	No relaxation
21	Selenium as Se, Max	0.01	Beyond this, the water becomes toxic	No relaxation
22	Arsenic as As, Max	0.05	Beyond this, the water becomes toxic	No relaxation
23	Cyanide as CN, Max	0.05	Beyond this, the water becomes toxic	No relaxation
24	Lead as Pb, Max	0.05	Beyond this, the water becomes toxic	No relaxation
25	Zinc as Zn, Max	5	Beyond this limit it can cause astringent taste and an opalescence in water	15
26	Anionic detergents as MBAS, Max	0.2	Beyond this limit it can cause a light froth in water	1.0
27	Chromium as Cr^{6+}, Max	0.05	May be carcinogenic above this limit	No relaxation
28	Ploynuclear aromatic hydrocarbons as PAH, Max	---	May be carcinogenic	---
29	Mineral Oil, Max	0.01	Beyond this limit undesirable taste and odour after chlorination take place	0.03
30	Pesticides, Max	Absent	Toxic	0.001
31	Radioactive materials a) α emitters Bq/1, Max b) β emitters Pci/1, Max	 --- ----	 ---- ----	 0.1 1
32	Alkalinity, Max	200	Beyond this limit taste becomes unpleasant	600
33	Aluminum as Al, Max	0.03	Cumulative effect is reported to cause dementia	0.2
34	Boron, Max	1	-----	5