Report on mapping and study of selected Tsachhus/Hotsprings and Menchhus/ Mineral springs in Bhutan

(Comparative profile between Scientific and Sowa Rigpa perspectives)

Traditional Medicine Division
Department of Health Services
Ministry of Health, Thimphu

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ACKNOWLEDGEMENT

Traditional Medicine Division would like to extend our heartfelt gratitude to the following officials and professionals for their invaluable guidance, support, and contributions to this study:

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2. Nima Dorji, RCDC,Thimphu
3. Sonam Dorji, Menpa, DoTMS
4. Sonam Lhundrup, P.O, TMD, DHS
5. Drg. Dorji Gyeltshen, NTMH
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ABBREVIATIONS

APHA	American Public Health Association
BDWQS	Bhutan Drinking Water Quality Standard
CaCO3	Calcium Carbonate
CFU	Colony forming unit
DTMS	Department of Traditional Medicine Services
FoTM	Faculty of Traditional Medicine
GHT	Greater Himalayan Thrust
HDPE	High-density Polyethylene
HFT	Himalayan Frontal Thrust
ICP-OES	Inductively coupled plasma optical emission spectroscopy
KGUMSB	Khesar Gyalpo Univeristy of Medical Sciences of Bhutan
MBT	Main Boundary Thrust
MCL	Maximum contaminant levels
MCT	Main Central Thrust
MFT	Main Frontal Thrust
ND	Not Detected
NTU	Nephelometric Turbidity unit
PES	Polyethersulfone
ps/cm	µS/cm : microsiemens per centimeter
RCDC	Royal Centre for Disease Control
SPADNS	Sulfo Phenyl azo Dihydroxy Naphthalene Disulfonic Acid
TDS	Total Dissolve Solvents
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

FORWORD

Bhutan is home to numerous hot springs, known as Tshachhu, and mineral springs, called Menchhu, which possess unique geothermal characteristics. These springs are spread across various parts of the country and are deeply intertwined with Bhutanese socio-cultural history, tracing their origins back to the visit of Guru Rinpoche and the advent of Mahayana Buddhism in 764 AD. They are considered blessed by Buddha and Bodhisattvas.

For centuries, the Bhutanese have utilized Tshachhu and Menchhu to treat a variety of ailments such as skin diseases, joint pains, arthritis, sinusitis, body aches, and chronic gout. Menchhus are also used for treating dislocations, fractures, and wounds. Each Tshachhu and Menchhu is believed to have its own unique healing properties. Apart from their therapeutic benefits, these springs are revered for their spiritual significance and are considered sacred sites. Many Bhutanese families travel to these springs for holistic baths, not only to seek cures for various diseases but also for relaxation and recreation, often camping in these areas for days.

In addition to therapeutic uses, people drink the waters from Tshachhus and Menchhus and even use them for cooking while camping in the areas. While some springs are widely known and popular, others remain relatively unknown despite their perceived healing properties and spiritual importance.

To better understand and utilize these natural resources, the Traditional Medicine Division (TMD) has mapped all Tshachhus and Menchhus in the country. In collaboration with the Royal Centre for Disease Control under the Ministry of Health and KGUMSB, TMD conducted a detailed physio-chemical and microbiological profiling study in 2020. This study also included information from the gSowa-Rigpa perspectives of some of the renowned Tshachhus and Menchhus.

The findings from this study are expected to assist in disseminating health advisories to the general public and serve as evidence for planning nature-based health and wellness tourism in Bhutan

Pemba Wangchuk
SECRETARY
Ministry of Health

Distribution of Tshachhus and Menchhus in Bhutan

Summary Table

Tshachhu

Dzongkhag	Sl. No.	Name of Tshachhu	Gewog	Chiwog
Bumthang	1	Dhur Tshachhu	Choekhor	Dhur
	2	Pasanglum Tshachhu	Choekhor	Dhur
Gasa	3	Gasa Tshachhu	Khatoe	Rimi
	4	Gayza Tshachhu	Laya	Gayza_Lung-go
	5	Waychey Tshachhu	Lunana	Shang_Threlga_ Wachey
Lhuentse	6	Khambaneylung Tshachhu	Gangzor	Nye
	7	Yontenkuengjong Tshachhu	Gangzor	Nye
Punakha	8	Chhuboog Tshachhu	Chhuboog	Jangwakha_Sewala
	9	Koma Tshachhu	Geonshari	Zhelngoesa
Sarpang	10	Gelephu Tshachhu	Serzhong	Serzhong
Zhemgang	11	Duenmang Tshachhu	Nangkhor	Duenmang

1.1. Menchhu

Dzongkhag	Sl. No.	Name of Tshachhu	Gewog	Chiwog
Gasa	1	Jagay Menchhu	Khatoe	Rimi
	2	Tokay Menchhu	Khatoe	Rimi
	3	Yama Menchhu	Khatoe	Rimi
	4	Gama Menchhu	Khatoe	Rimi
	5	Zama Menchhu	Khatoe	Rimi
	6	Bayken Menchhu	Khatoe	Chogley_ Phulakha
	7	Menchhu karpo	Khatoe	Chogley_ Phulakha
	8	Madhey Menchhu	Khatoe	Chogley_ Phulakha

Dzongkhag	Sl. No.	Name of Tshachhu	Gewog	Chiwog
Gasa	9	Lhogok Menchhu	Khatoe	Chogley_ Phulakha
	10	Aekay Menchhu	Khatoe	Rimi
	11	Tongchhu Menchhu	Laya	Gayza Lung-go
Haa	12	Kajina Menchhu I	Katsho	Bali
	13	Kajina Menchhu II	Katsho	Bali
	14	Kajina Menchhu III	Katsho	Bali
	15	Gerina Menchhu	Ueso	Gerina-karnag
	16	Nobgang Menchhu	Samra	Langpa-Nobgang
	17	Agchuna Menchhu	Shari	Fentena-Sertena
	18	Chugumna Menchhu	Shari	Fentena-Sertena
	19	Bjisungkha Menchhu	Shari	Fentena-Sertena
	20	Lomai Menchhu	Ueso	Kipri Tagchhu
	21	Takchugeonpa Menchhu	Ueso	Kipri Tagchhu
	22	Meguena Menchhu	Ueso	Sangkiri
	23	Gamara Menchhu	Bji	Chumpa
	24	Chukarpo Menchhu	Bji	Talung
	25	Chuba Menchhu	Bji	Chumpa
	26	Macca Menchhu	Bji	Chumpa
	27	Loloi/Pachen Menchhu	Bji	Talung
	28	Rabchuzampa Menchhu	Bji	Talung
Paro	29	Dobji Drupchhu/ Menchhu	Dokar	Tshongkha
	30	Dozo Menchhu	Dokar	Tshongkha

Dzongkhag	Sl. No.	Name of Tshachhu	Gewog	Chiwog
Paro	31	Bugo Menchhu	Dokar	Sali
	32	Tari Menchhu	Dokar	Sali
	33	Dama Menchhu	Doteng	Jabji Loogchoed
	34	Chumeygaytsa Menchhu	Doteng	Atsho Phunub
	35	Dampakha Menchhu	Doteng	Phushar
	36	Phazhi Menchhu	Doteng	Atsho
	37	Ramshingkha Menchhu	Doteng	Chhubar
	38	Dagaphu Menchhu	Lamgong	Gongju
	39	Gongju Menchhu	Lamgong	Gongju
	40	Longona Menchhu	Lamgong	Gongju
	41	Dago lewkha Menchhu	Lamgong	Jagathang
	42	Chowai Menchhu	Shaba	Heyphu
	23	Jabtokha Menchhu	Shaba	Zhelngo
	44	Sarbu Menchhu	Shaba	Zhelngo
	45	Wachey Menchhu	Shaba	Zhelngo
	46	Yeulay Menchhu	Shaba	Zhelngo
	47	Jagay Menchhu	Tsatsam	Nichu
	48	Baykhen Menchhu	Tshento	Mesta
	49	Chinju Yama Menchhu	Tshento	Chinju
	50	Chakha Menchhu	Tshento	Metse
	51	Chudephu Menchhu	Tshento	Chudephu
	52	Damphu Menchhu	Tshento	Zamsa

Dzongkhag	Sl. No.	Name of Tshachhu	Gewog	Chiwog
Paro	53	Dotasha Menchhu	Tshento	Namjee
	54	Doshong Menchhu	Tshento	Shana
	55	Kalungkha Menchhu	Tshento	Namjee
	56	Tongzhi Menchhu	Tshento	Metse
	57	Kheldo Menchhu	Tshento	Metse
	58	Lamdo Menchhu	Tshento	Shana
	59	Nebla Menchhu	Tshento	Jetsephu
	60	Rokhai Menchhu	Tshento	Zamsa
	61	Tsenjo Menchhu	Tshento	Shari
	62	Wanna Menchhu	Tshento	Gomey
Punakha	63	Tana Menchhu	Mendrelgang	Wolakha
S/Jongkhar	64	Gonong Menchhu	Gomdar	Gonong
	65	Monmola Menchhu	Serthi	Serthi
	66	Sanglam Menchhu	Serthi	Serthi
	67	Raling (Nanital) Menchhu	Pemathang	Raling
	68	Tarolung zorkang Menchhu	Pemathang	Raling
Thimphu	69	Menchu Karpo	Kawang	Kabesa
	70	Chukhor Menchu	Kawang	Kabesa
Zhemgang	71	Dangkhar Menchu	Nangkor	Dangkhar
Bumthnag	72	Pangkhar Menchu	Ura	Pangkhar
	73	Shingkhar Menchu	Ura	Shingkhar
Wangdue Phodrang	74	Rabgay Menchu	Thnagyuel	Thangyuel

EXECUTIVE SUMMARY

A total of 11 Tsachhus and 74 Manchus were mapped out located in different parts of the country as indicated in the summary table. Out of these 5 renowned Tshachhuus namely Gasa Tsachhu, Chhubo Tsachu, Koma Tsachhu, Gelephu Tsachhu , Dunmang Tsachhu and 13 renowned Menchuus under Gasa, Paro, Thimphu,Wangdue Phodrang , Samdrup Jongkhar and Zhemgang Dzongkhags were included as representative samples for the mineral content study.

In order to build the evidence on the physicochemical profile of the Tsachhus and Menchhus the study included the 3 categories of parameters such as physical, trace element & heavy metals and some chemical-inorganic content of the water. In case of physical parameters and Gasa Tshachhu has high turbidity ranging from 5.82 to 13.6 NTU, and temperature varies from 34 – 40.3 ℃. Gelephu Tsachhu has turbidity 1.53 to 6.22 NTU and temperature varies from 31.6 to 34.3 ℃. The temperature of Chubu Tshachuu ranges from 43.1 to 46.1 ℃, temperature of of Koma Tsachu ranges from 31.6 to 38 oC. Temperature of Donmang Tsahchhu ranges from 39.9 to 48.4 ℃ which is the highest temperature and 31.6 ℃ at Koma Tshachhu the lowest temperature among the Tshachhus.

On the trace elements and heavy metals Gasa Tshachhu has high Arsenic ranging from 0.373 to 0.604 mg/l. and Gelephu Tshachhu has Arsenic ranging from 0.004 to 0.013 which is below normal standard, Chubu and Khoma Tshachhu has lead ranging from 0.001 mg/l which is very much lower than normal range and rest of the parameters in all Tshachhus were within and below normal range of WHO and BDWQ standard. On the chemical –inorganics the findings were within normal range of WHO and BDWQ standard in all the Tsachhus.

On the microbial profile Gasa Tsachhu has Thermo tolerant Coliform ranging from 3 to39 in pond1, pond 2 and royal pond and Gelephu Tsachhu has 36 to 52 in Pond 1, pond 2, pond 3 and Pond 4.

Among the Menchhus, Jagay Menchhus, Gasa has turbidiy of 7.05, Dangkar menchu at Zhemgang has 14.32, Raling menchu at Bangtar, s/Jongkhar has 30.08 as the highest trubidity. On the microbial Chagoe Menchu,paro has thermotolerent coliform 176,followed by dangkar menhcu 21, and torizorkagbg S/Jongkhar Menchu 8 , Railing and Rabgay Menchu, Wangdue phodrang 3, Gonong Menchu, S/jonkhar 2, Tongzzhi Menchu,Paro1.

On the trace elements and heavy metal, Kabisa Choekor Menchu has Arsenic 0.0174, Dobji Drupchu has 0.0166, Jagoe Menchu, Gasa has 0.026, Tokey Menchu, Gasa has 0.016, Menchu karpo at kabisa, Thimphu has 0.014, Drugyel and Raling Menchu has 0.013, rest of the elements are within normal range. Jagae and Tokey Menchhu at gasa has higher fluoride and Manganese and Raling and Torizorkang menchhu at S/jongkhar also have high Manganese.

Overall Tshachhus have higher sulphates than Menchhus and Manchus have higher calcium (1705.58) than Tsachus. Lead is not detected in all Menchhus, Tshachhus have higher Arsenic (0.604) compared to Menchhus. Tshachus have higher alkalinity (1864.5) than Menchhus.

Comparison of mineral contents in the Tshachhus from the scientific and Sowa rigpa perspectives revealed close matching, where the common minerals content are calcium, sulphate, zinc and potassium in both the findings. This indicates that there are some similarities between science and Sowa Rigpa.

In Bhutan, some Tshachhus have high arsenic levels, a unique concern. Additionally, coliform microbes indicate faecal contamination, requiring urgent public health intervention. Lastly, all Tshachhus are sulphate-rich, necessitating awareness of the risks associated with drinking, cooking, and inhalation.

BACKGROUND

Mineral water is a natural solution formed under a specific geological condition and is characterized by chemico-physical dynamism. Hot spring is a natural source of hot water that gets heated by the geothermal gradient beneath the earth and ultimately rises up to the earth's surface through the fissures or fractures of the rocks. The major sources of heat, which make spring water hot, are magmatic, radioactive disintegration, thermal gradient, and chemical changes within the earth's crust (Sterns et al., 1937). Hot springs are mostly originated in the area of volcanoes (e.g. in Japan) and in the area of young tectonic belts (e.g. in Bhutan, Nepal). The chemical composition of any particular hot spring depends on the chemical composition of the host rocks through which it seeps. (Geothermal Resource of South Asia, 2011)

Hot or geothermal and mineral springs fall into the category of natural resources (Rai et al., 2020) and the only differences between them are the varying temperature and their mineral content (Erfurt et al., 2011). They have been used for bathing and well-being purpose all over the world (Hamzah et.al. 2013) with historical and cultural values (Erfurt et al., 2011).

Globally, Geothermal and mineral water has been utilized for various purposes. In New Zealand, North America, and other areas it was utilized for cooking, bathing and for well-being purposes. Similarly, the Romans used for eye and skin diseases, the Europeans, for health attraction and Japan is considered a world leader in balneology. Based on archaeological findings, mineral waters have been used for bathing since the Bronze Age above 5000 years ago (Jabbour et.al., 2013, Rai et al., 2020, p. 25).

However, the health values of hot springs are directly linked to the type of minerals and metallic trace elements present. (Parish and Lotti, 1996). Numerous existing literature suggests that the positive health effects are directly related to the absorption of mineral ingredients and metallic trace elements through the skin. The beneficial effects for the human body include the support of the healing process for a variety of health conditions. Some examples of minerals known for their curative benefits are Calcium, Chloride, Fluorine, Iron, Magnesium, Potassium, Silica, Sodium and Sulphate.

The Geographical location of Bhutan in Himalayas has not only favoured the people with the Diverse Flora and Fauna but also blessed with the enriched natural healing elements. The hot and mineral springs of Bhutan were considered as medically as well as sociologically important (Hembry, 1990; Goodrich and Uysal, 1994; Korea, 2005; Nakata, 2008; Das et al. 2012).

In Bhutan, natural hot and mineral springs are literally known as 'Tsachus' and 'Menchus'and are highly revered for their spiritual significance and curative powers (Wangchuk & Dorji, n.d.) as it is believed they have been blessed by the divine hands of Guru Rinpoche in the 8th century (Dorji et.al., 2014). For, this reason, they are considered sacred with healing powers to treat various ailments (Dorji et.al, 2014).

In Bhutan, there are 11 hot springs (Dhur Tshachhu and Pasanglum Tshachhu in Bumthang, Gasa Tshachhu, Gayza Tshachhu and Waychey Tshachhu in Gasa, Khambaneylung Tshachhu and Yontenkuengjong Tshachhu in Lhuentse, Chubu Tshachhu and Koma Tshachhu in Punakha, Gelephu Tshachhu in Sarpang and Duendmang Tshachhu in Zhemgang) present in Bhutan. Currently, there are 74 Menchus in 6 districts (Gasa, Haa, Paro, Punakha, Samdrup Jongkhar, Wangdue Phodrang and Bumthang) which were mapped out and verified. However, there are very limited studies available on the specific properties, safety, and efficacy of the Tsachus and Menchus. In 1999 to 2007, Drungtsho Yeshi Dorji led and conducted few studies from the gSowa-Rigpa perspectives but the study of mineral content from the scientific and gSowa- Rigpa perspectives were not conducted so far.

Therefore, DTMS under the Ministry of Health had undertaken this study in collaboration with RCDC and FoTM, KGUMSB to map the Tsachhus and menchhus with their place of to develop national index and inventory list. Additionally, to describe the physicochemical profile of renowned Tshachhu and Menchhu in both gSoba-Rigpa and scientific perspectives.

Purpose of the study

1. Mapping Purpose: The first purpose was to map out the total number and locations of all Tsachhus (hot springs) and Menchhus (medicinal waters) throughout Bhutan.
2. Physicochemical Profile Purpose: The second purpose was to describe the physicochemical profiles of renowned Tsachhus and Menchhus according to both gSoba-Rigpa (traditional Bhutanese medicine) and scientific perspectives.
3. Comparison Purpose: The third purpose was to compare the mineral and chemical content of these waters from both scientific and Sowa Rigpa (traditional medicine) perspectives.

Objective of the study

1. Determine the physicochemical profile of Tshachhu and Menchhu as per gSoba-Rigpa and scientific perspective.
2. To develop national index and inventory on Tshachhu and Menchhu

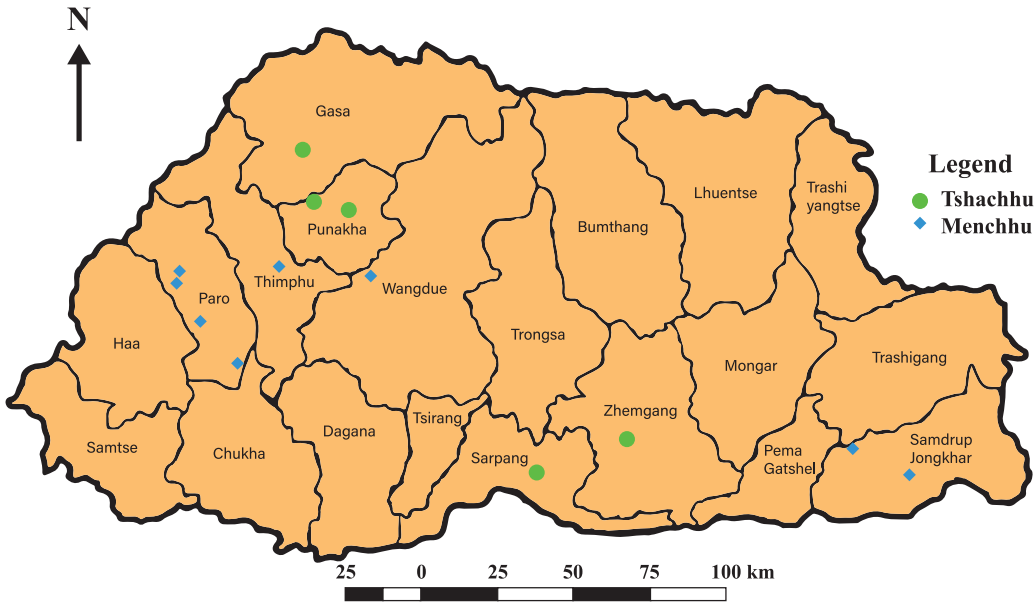
METHODOLOGY

Study design

The current study utilized a quantitative approaches with focus on a systematic process of describing the physicochemical profile of renowned Tshachhu and Menchhu as per gSoba-Rigpa and scientific perspective.

Study site

A convenience sampling method was applied in this study where about 5 renowned and most frequently visited Tshachhus and 13 Menchhus were predetermined as study sites. The study was conducted for 5 renowned Tshachhus and 13 Menchhus at Gasa, Punakha, Paro, Sambdru Jongkhar and Zhemgang Dzongkhag.



Data collection tools and Materials

4.2.1. GPS - Geographical coordinates

4.2.2. Thermo scientific Orion star A220 - Temperature, conductivity and TDS

4.2.3. Hanna Turbidity Meter (HI93703) - Turbidity

4.2.4. Portable pH meter Mettler Toledo FiveGo pH meter.

4.2.5. HACH DR 5000 UV Spectrophotometer - Chemical analysis

4.2.6. Titration technique

4.2.7. Agilent ICP-OES 5110

4.2.8. APHA 20th edition method 9222 D Fecal Coliform membrane filtration technique

4.2.9. DelAgua field water testing kit.

Data Collection procedure

During the initial line listing, a total of 11 Tshachhus and 74 Menchhus were listed from at 11 Districts. However, due to various reasonsthe data collection was conducted from only 5 renowned Tshachhu and 13 Menchhus.The data collection team consisted of technical core group from the Royal Centre for Disease Control, Faculty of Traditional Medicine and the Department of Traditional Medicine Services. A semi-structured data collection sheet with focus on the physico-chemical parameters was developed in both Dzongkha and English as per scientific and gSoba-Rigpa perspectives. Sample collection and documentation of each Tshachhus and Menchhu was conducted by the technical core group members.

Water Sample Collection methods

From the 5 Tshachhus, a total of 22 samples were collected from 2 ponds of Chubu Tshachhu, 4 ponds of Koma Tshachhu in Punakha, 6 ponds of Duenmang Tshachhu in Zhemgang, 6 ponds of Gasa Tshachhu in Gasa, and 4 ponds of Gelephu Tshachhu in Sarpang districts. A total 13 Menchhus samples were collected from 2 Menchhus in Gasa, 4 Menchhus in Paro, 3 Menchhus in Samdrupjongkhar, 2 Menchhus in Thimphu, 1 Menchhus in Wangdiphodrang and 1 Menchhus in Zhemgang Districts.

A standard quantity of 1000 ml sample was collected in a high-density polyethylene HDPE container for measuring inorganic chemical parameters. 250 ml of water sample was also collected in HDPE container, which was then immediately acidified using AR Grade Nitric Acid to pH <2 for elemental analysis using ICP-OES. Another 250 ml was immediately brought to the laboratory in sterile containers for microbial analysis. All the samples were transported to the laboratory maintaining optimum temperature of <8°C. Some of the physicochemical parameters were measured at the site using portable field test kits. All the samples were collected and preserved as per the sample collection and preservation protocols 1060 of APHA, 20th edition. SOPs for sample collection, preservation and transportation of RCDC were also referred.

Study variables

The study variables were categorised under physical, chemical, microbial and Sowa Rigpa properties.

Physical parameters

The physical parameters include temperature, pH, turbidity, conductivity and TDS. Most of the parameters were measured and analysed using portable water test kits at sampling sites. However, further analysis and measurement of temperature, conductivity and TDS were done in the lab using Thermo scientific Orion star A220 and Turbidity using Hanna Turbidity Meter (HI93703). The pH of the samples was determined using a portable pH meter Mettler Toledo FiveGo pH meter.

Chemical parameters

HACH DR 5000 UV Spectrophotometer is used to analyse Fluoride, Nitrate and Sulphate in all the samples. Total Hardness, Calcium Hardness and Alkalinity were measured using Titration technique. Other elements were analysed using Agilent ICP-OES 5110.

Microbial analysis

Thermotolerant coliform was analyzed using APHA 20th edition method 9222 D Fecal Coliform membrane filtration technique. As the samples could not be transported within 24 hours to the laboratory, DelAgua field water testing kit was used to test thermotolerant coliform at the sampling sites.

Data processing and analysis

After verification and cleaning the data, a descriptive analysis was performed through Microsoft excel. Further, a detailed profile of the physicochemical profile was carried out for each Tshachhus and Menchhus (5 Tshachhus and 13 Menchhus). Data analysis was focused on four components such as; physical, chemical, microbials and comparison of findings between gSoba-Rigpa and scientific perspective. MCL (Maximum contaminant levels) as per BDWQS was followed as a standard reference.

RESULTS

The result section includes Geographical coordinates, detailed laboratory tests including Physical, Chemical and Microbiological tests, Sowa Rigpa properties, and Comparative-scientific and gSowa-Rigpa findings of Tshachhu and Menchhu.

Tshachhu

Physical parameters

At all five tshachhus, all the physical parameters are within the recommended value as per USEPA and WHO standard for drinking water. However, each tshachhu had unique feature. Gasa tshachhu was acidic and had high turbidity. On the other hand, Koma tshachhu had alkaline pH (8.18-8.93). Duenmang Tshachhu was the hottest of all the five Tshachhus. While, Gelephu Tshachhu had highest conductivity and TDS compared to the rest. For detail refer table 1.

Chemical parameters

In all five tshachhus, almost all the chemical parameters were within acceptable limits required for drinking water as per USEPA and WHO. However, a high level of arsenic was present in all the ponds from Gasa Tshachhu (almost 60 times higher than recommended values of Arsenic in drinking water (0.01mg/l)). Similarly, Chubu Tshachhu had the highest concentration of Aluminium. Also, Koma Tshachhu had high levels of aluminium and Zinc. While, Gelephu has the highest concentration of fluoride, calcium and sulphate compared to other Tshachhus. Fluoride was higher than normal even in Duenmang tshacchu. For detail refer table 2a and 2b.

Microbial

Chubu, Duenmang and Koma tshachhus were free of Thermotolerant coliform. As per BDWQS, thermtolerant Coliform should not be contain in drinking water. However, both Gasa and Gelephu Tshachhus had shown the presence of Coliform. Of the two, Gelephu Tshachhu had highest amount of Thermotolerant coliform count indicating faecal contamination. For details refer table 2a.

Table 1: Demonstrating the physical parameters of five selected tshachhus in Bhutan, 2023.

Tshachhu	Sampling sites	Altitude	Temperature (°C)	pH	Conductivity (ps/cm)	TDS (mg/l)	Turbidity (NTU)
Chubu, Punakha	Upper Pond	1850	43.40	8.42	601.40	295.20	0.66
	Lower Pond	1840	46.10	8.82	597.10	288.00	0.35
Koma, Punakha	Pond 1	1840	31.60	8.18	329.70	162.10	0.36
	Pond 2	1860	35.00	8.41	383.30	187.10	0.41
	Pond 3	1810	36.00	8.93	336.50	165.10	0.25
	Pond 4	1810	38.00	8.93	391.50	176.10	0.32
Gasa Tshachhu	Pond 1	2170	37.90	6.49	844.70	417.70	13.60
	Pond 2	2170	35.30	6.50	873.20	425.20	10.70
	Pond 3	2170	34.70	6.64	915.50	447.10	11.20
	Pond 4	2170	40.60	6.58	931.30	452.50	12.30
	Royal Pond	2170	34.00	6.51	853.60	412.90	5.82
	VIP Pond	2170	40.30	6.67	928.50	442.20	10.10
Gelephu Tshachhu	Pond 1	315	33.30	6.52	923.30	452.90	4.10
	Pond 2	315	34.30	6.38	923.90	453.20	6.22
	Pond 3	315	34.20	6.33	943.70	462.90	5.04
	Pond 4	315	31.80	6.44	976.90	479.20	1.53
Duenmang Tshachhu, Zhemgang	Pond 1 A	296	43.90	7.39	496.00	243.50	0
	Pond 1 B	296	39.90	7.64	455.60	223.70	0
	Pond 2 A	290	47.20	6.98	597.10	284.30	0
	Pond 2 B	290	45.90	7.40	577.40	283.40	0
	Pond 3	296	46.00	7.51	501.70	246.30	0
	Pond 4	296	48.40	7.51	516.50	248.40	0

Table 2a: Illustrating the inorganic and microbial parameters of five selected tshachhus in Bhutan, 2023.

Tshachhu Name	Sampling sites	Fluoride (mg/l)	Nitrates (mg/l)	Sulphate (mg/l)	Calcium Hardness (mg/l as CaCO3)	Total Hardness (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)	Coliform (CFU/100ml)
Chubu, Punakha	Upper Pond	ND	1	13	10.10	94	419.60	0
	Lower Pond	ND	0.80	3	10.70	99	504.70	0
Koma, Punakha	Pond 1	ND	1	13	16.60	201	68.5	0
	Pond 2	ND	0.80	3	7.90	123	85	0
	Pond 3	ND	1	10	14.40	177	77.5	0
	Pond 4	ND	0.90	4	12.10	195	80.5	0
Gasa Tshachhu	Pond 1	ND	4.1	40	157.8	409.2	1707	34
	Pond 2	ND	4.5	44	163.3	442	1794	3
	Pond 3	ND	4	39	129	451.2	1803	0
	Pond 4	ND	4.3	43	120	454.7	1864.5	0
	Royal Pond	ND	4.6	35	88.1	397.8	1676	10
	VIP Pond	ND	5.1	39	120	441.7	1821.5	0
Gelephu Tshachhu	Pond 1	0.76	0.30	210	266.4	269.9	491.2	43
	Pond 2	0.71	0.40	200	262.7	271.2	482.8	52
	Pond 3	0.72	0.90	210	259	265.7	474.0	41
	Pond 4	0.76	0.40	240	262.2	265.5	469.0	36

Duenmang Tshachhu, Zhemgang	Pond 1 A	0.24	0.50	50	179.8	183	363.2	0
	Pond 1 B	0.23	0.50	40	172.1	175.7	264.9	0
	Pond 2 A	0.25	0.30	90	222.9	223.8	348.0	0
	Pond 2 B	0.45	0.70	110	223.9	224.6	346.8	0
	Pond 3	0.43	0.50	70	190.3	192.8	355.9	0
	Pond 4	0.39	0.39	70	201.9	202.4	359.9	0

Table 2b: Demonstrating the trace elements and heavy metals of Tsachhu measures in mg/L in five selected tshachhus in Bhutan, 2023.

Tshachhu Name	Sampling sites	A1	As	Ba	Co	Mn	Mo	K	Se	Sr	Zn
Chubu, Punakha	Upper Pond	0.054	ND	0.002	ND	0.006	0.004	2.214	ND	0.022	ND
	Lower Pond	0.137	ND	0.007	ND	0.014	0.002	2.549	ND	0.027	0.035
Koma, Punakha	Pond 1	0.133	0.003	0.006	ND	0.003	0.001	1.602	ND	0.015	ND
	Pond 2	0.035	0.025	0.004	ND	0.001	0.001	1.335	ND	0.014	ND
	Pond 3	0.119	ND	0.006	ND	0.002	ND	1.210	0.001	0.015	0.057
	Pond 4	0.081	ND	0.004	ND	ND	0.001	1.142	ND	0.013	ND
Gasa Tshachhu	Pond 1	0.055	0.373	0.553	0.003	0.075	0.006	158.051	0.017	1.611	0.001
	Pond 2	0.049	0.347	0.570	0.004	0.072	0.003	168.707	0.004	1.740	ND
	Pond 3	0.072	0.604	0.600	0.003	0.070	0.006	170.073	0.018	1.771	0.013
	Pond 4	0.050	0.522	0.596	0.004	0.076	0.004	171.694	0.025	1.805	ND
	Royal Pond	0.046	0.419	0.541	0.002	0.079	0.003	155.051	0.011	1.650	ND
	VIP Pond	0.048	0.358	0.563	0.004	0.074	0.003	166.247	0.014	1.772	ND

Tshachhu Name	Sampling sites	A1	As	Ba	Co	Mn	Mo	K	Se	Sr	Zn
Gelephu Tshachhu	Pond 1	0.067	ND	0.045	0.003	0.050	ND	23.520	0.011	5.218	0.009
	Pond 2	0.049	0.004	0.046	0.003	0.050	ND	23.924	ND	5.121	0.012
	Pond 3	0.057	0.015	0.044	0.002	0.049	ND	24.334	0.002	5.192	0.003
	Pond 4	0.049	0.013	0.040	0.004	0.061	ND	26.568	0.019	5.207	0.006
Duenmang Tshachhu, Zhemgang	Pond 1 A	0.022	0.001	0.073	0.003	0.002	ND	11.008	ND	1.233	ND
	Pond 1 B	0.023	0.012	0.077	0.001	ND	ND	9.872	ND	1.110	0.001
	Pond 2 A	0.049	ND	0.068	0.003	0.001	ND	12.381	ND	1.727	0.019
	Pond 2 B	0.028	0.013	0.063	0.003	ND	ND	12.291	ND	1.718	ND
	Pond 3	0.024	0.001	0.076	0.002	ND	ND	10.625	ND	1.337	ND
	Pond 4	0.042	0.013	0.075	0.003	ND	ND	11.305	ND	1.474	0.009

Footnote: *Chromium and Nickel were not detected (ND), Lead was detected in only third pond of Koma Tsachu and lower bound of Chubu Tsachu with highest level of 0.001 mg/l, Cadmium is detected only at Duenmang, Gelephu and pond 1 of Gasa Tsachu with highest level of 0.001 mg/l and Copper is detected only at Duenmang and Gelephu Tsachu with highest value of 0.006*

Table 3: Demonstrating Sowa Rigpa based properties observed in five tshachhus in Bhutan 2023.

Properties	མགར་སྟ་ཚ་ཆུ།	ཆུ་སྲུག་ཚ་ཆུ།	དགེ་ལེགས་ཕུག་ཚ་ཆུ།	ཀོ་མ་ཚ་ཆུ།	བདུན་མངར་ཚ་ཆུ།
སྨན་རྫས།	རྡོ་སོལ། ལུ་ལྕང་། ཅོང་ཞི། རྡོ་ཆུ།	རྡོ་སོལ། ཅོང་ཞི།	རྡོ་སོལ། ལུ་ཟི། ཅོང་ཞི།	རྡོ་སོལ། ཅོང་ཞི། རྡོ་ཆུ། བག་ལྷུན། རྡོ་ཞོ།	རྡོ་སོལ། ལུ་ཟི། ཅོང་ཞི། རྡོ་ཞོ།
དྲི།	སྐོང་རྡོའི་དྲིམ།	སྐོང་རྡོའི་དྲིམ།	ར་གཞོག སྐོང་རྡོའི་དྲིམ།	སྐོང་རྡོའི་དྲིམ།	སྐོང་རྡོའི་དྲིམ། ར་གཞོག
མདོག	སྔོ་སྐྱ། དཀར་པོ། སྔོ་དམར། སྔོ་གནག།	སྔོ་སྐྱ།	སྔོ་སྐྱ།	དཀར་པོ། སྔོ་སྐྱ།	སྔོ་སྐྱ།
ཚུའི་གར་ལྡོག	སྤུ་བ། བསྐྱ་སྤུ་སྟོམས་པ།	དྲངས་བ། སྤུ་བ།	དྲངས་བ། སྤུ་བ། བསྐྱ་སྤུ་རན་པ།	དྲངས་བ། སྤུ་བ།	དྲངས་བ།
ཚན་ཉམ།	གྲང་བའི་ནད་ རིགས་དང་ བད་ཀན་ལྷེན་སྐྱེན་ མ་ཤུ་བ་ རྒྱ་ཆད་ དང་ བད་ཀན་ སྨྲག་པོ་ཚུ་ལུ་ ཚན། ཆུ་སེར་དང་ཚ་ བའི་ནད་ལ་ཚན།	བད་ཚད་ཀྱི་ ནད་གཞི་ཚུ་ ལུ་ཚན།	གྲང་བའི་ནད་ གཞི་ལུ་ཚན།	བད་ཚད་ཀྱི་ནད་ དང་མ་ཤུ་བ་ རྒྱས་ཆགས་ཚུ་ལུ་ ཚན། ཚ་བ་ཆུ་སེར་ནད་ གཞི་ཚུ་ལུ་ཚན།	གྲང་བ་ཆུ་སེར་ནད་ གཞི་ཚུ་ལུ་ཚན།

The findings of the RCDC tests mostly matched the mineral contents, odour and colour. However, there are discrepancy in the defining the turbidity as provided in the following table 4.

Table 4: Demonstrating the comparison of Sorig properties to that of RCDC results.

Properties	Sorig findings	RCDC resultx
Mineral Contain	རྡོ་སོལ། ཟུ་ཟེ། ཅོང་ཁེ།	Coal, Sulphate, Calcium hardness
Odour	ར་གཞོན། སྐྱང་རྡོའི་དྲིམ།	Sulphate
Colour and Turbidity	སྔོ་སྐྱ།/ ལྗ་བ། སྔོ་སྐྱ།/ བསྐ་ལྗ་རན་བ། དཀར་སྐྱ། དཀར་པོ། སྔོ་སྐྱ།/ དྭངས་བ། ལྗ་བ།	Turbidity – High (10-13) Turbidity – Medium (4-6) Turbidity – Low (<3)

Menchhu

In all the thirteen menchhus, both the physical and chemical parameters were within acceptable value recommended by USEPA and WHO for drinking water. However, Jagay Menchhu, Drugyel Menchhu, Rabgay Menchhu and Tokay Menchhu were found to be acidic in nature. Raling Menchhu had 30.08NTU of turbidity, which is exceptionally higher than the recommended value for drinking water. Also, Raling menchhu was alkaline with alkalinity value of 1377.9 mg/l as CaCO3 as shown in table 5.

Jagay menchhu also had the highest concentration of Arsenic level. Dobji drupchhu, Drugyel Mnechhu, Kabesa chukhor menchhu, Kabesa Menchhu Karpo and Raling Menchhu had slightly higher arsenic level than recommended value of drinking water as shown in table 6b

Nearly all the menchhus were free of the thermotolerant coliform growth (0 cfu/100mL) indicating free of fecal contamination. However, Bjagay Menchhu at Paro is found to be grossly contaminated by fecal source and had more than 100 cfu/100mL sample thermotolerant coliform growth. Dangkar menchhu was possibly contaminated as indicated by presence of thermotolerant coliform as shown in table 6a.

Table 5: Demonstrating the physical Properties of 13 selected Menchhus of Bhutan, 2023.

Dzongkhag	Name of the Menchu	Altitude	Temperature (°C)	pH	Conductivity (ps/cm)	TDS (mg/l)	Turbidity (NTU)
S/Jongkhar	Gonong	860	15.40	7.60	334.20	164.30	0
	Torizorkang	887	21.10	7.22	244.70	120.50	0.53
	Raling	NA	23	6.81	824.30	404.80	30.08
Gasa	Jagay	2240	12	6.30	409.60	199.90	7.05
	Toekay	2490	12.30	5.44	587.20	286.60	1.95
Paro	Drugyel	2580	NA	6.05	53.53	26.84	0.35
	Tongzhi	2580	NA	7.68	89.40	44.52	0.22
	Dobje	2200	NA	7.59	255.60	125.50	0.00
	Jagay	2700	NA	7.40	98.91	48.67	0.55
Wangdue	Rabgye	NA	19.40	5.83	528.3	254.40	0.07
Thimphu	Kabesa Menchhu Karpo	NA	NA	7.29	105.20	52.07	0.38
	Kabesa Chukhor	NA	NA	7.52	195.30	96.80	0
Zhemgang	Dangkhar	NA	16.50	6.64	113.50	56.49	14.32

Table 6a: Demonstrating inorganic and microbial properties in 13 selected Menchhus in Bhutan, 2023.

Dzongkhag	Menchu	Fluoride (mg/l)	Nitrates (mg/l)	Sulphate (mg/l)	Calcium Hardness (mg/l as CaCO3)	Total Hardness (mg/l as CaCO3)	Alkalinity (mg/l as CaCO3)	Thermotolerant Coliform (CFU/100ml)
S/Jongkhar	Gonong	0.69	0.20	10	166.30	167.40	440.30	2
	Torizorkang	0.12	0.40	10	110.60	111.80	398	8
	Raling	0.30	0.50	20	375.90	379.70	1377.90	3
Gasa	Jagay	1.51	1.70	42	56.90	597.90	1190	0
	Toekay	1.73	1.70	80	1705.58	287.10	197	0
Paro	Drugyel	0.22	0.40	ND	13.70	19.70	64.10	0
	Tongzhi	0.22	0.50	2	27.10	29.70	103.20	1
	Dobje	0.37	0.70	20	75.20	77.50	264	0
	Jagay	0.33	0.40	ND	45.90	47.20	141.80	176
Wangdue	Rabgye	0.73	0.40	ND	100.30	108.60	492.00	3
Thimphu	Kabesa Menchhu Karpo	0.88	0.50	6	25.50	26.20	121.00	0
	Kabesa Chukhor	0.29	0.80	ND	82.40	88.50	270.21	0
Zhemgang	Dangkar	0.12	0	0	32.30	33.50	68.60	21

Table 6b: Trace elements and heavy metal properties in 13 selected Menchhus in Bhutan, 2023.

Dzongkhag	Menchu	A1	As	Ba	Cd	Co	Cu	Mn	Mo	K	Se	Sr	Zn
S/Jongkhar	Gonong	0.012	0.006	0.057	ND	0.003	ND	0.002	ND	1.877	ND	0.077	0.004
	Torizorkang	0.030	ND	0.258	0.001	0.001	0.001	0.369	ND	2.715	ND	1.018	0.009
	Raling	0.090	0.013	0.643	0.001	0.004	0.009	0.205	ND	5.078	0.007	1.246	0.029
Gasa	Jagay	0.070	0.026	0.297	ND	0.003	ND	0.390	0.004	69.466	0.009	1.108	0.001
	Toekay	0.458	0.016	0.013	ND	ND	ND	1.166	0.003	4.412	ND	0.166	0.012
Paro	Drugyel	0.012	0.013	0.009	ND	ND	ND	0.072	0.001	1.177	ND	0.019	0.041
	Tongzhi	0.001	0.003	0.002	ND	ND	ND	ND	0.001	1.228	ND	0.034	0.022
	Dobje	0.020	0.017	0.021	ND	0.001	0.001	ND	0.001	3.761	ND	0.105	0.056
	Jagay	0.026	0.009	0.007	ND	0.001	ND	0.012	0.002	1.252	ND	0.011	0.048
Wangdue	Rabgye	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thimphu	Kabesa Menchhu Karpo	0.026	0.014	0.007	ND	ND	ND	0.012	0.001	1.309	ND	0.011	0.047
	Kabesa Chukhor	0.039	0.017	0.008	ND	0.001	ND	0.001	0.002	1.791	ND	0.104	0.076
Zhemgang	Dangkar	ND	ND	0.013	ND	0.001	ND	0.009	ND	2.047	ND	0.033	ND

Note: *Chromium, Lead and Nickel were not detected in any of the 13 menchhus.*

DISCUSSION

The therapeutic effects of *tshachhus* and *menchhus* are due to the combination of chemical, physical, immunological, and microbiological properties. The *tshachhus* and *menchhus* are associated with a lots of health benefits similar to what has been reported in many studies (Khole et al, Benbrahim et al, Sara et al, Norbert et al)

Physical parameters

Overall, all the physical parameters are within the recommended value as per USEPA and WHO standard for drinking water at all 5 tshachhus and 13 menchhus. Both *Chubu* and *Duenmang Tshachhus* fell into the category of Hyperthermal water (Sara et al). While the rest of the *Tshachhus* and *menchhus* were in the category of Homeothermic and hypothermal water category (Sara et al). However, temperature of *Tshachhus* are much lower compared to other places (Sara at ell and Norbert et al).

Hyperthermia has significant effects on granulocyte mobility and microbial and enzymatic activities. Apart from this, body exposure to thermal waters stimulates the immune and antioxidants. On the other hand, hyperthermal waters are used as short-term thermal stress and modifying the threshold of pain. (Sara et al). Please refer the table below for more information.

Table 7: Demonstrating the tshachhus, elements and perceived health benefits of Tshachhu.

Tshachhu	Most abundant elements	Perceived health benefits
Gasa	Sulphur, Nitrate, Calcium Bicarbonate	Skin regeneration, anti-inflammatory, and bactericidal activities
Chubu	Calcium, Almunium	Skin protection by improving natural defenses
Koma	Calcium, Almunium	Skin protection by improving natural defenses

Gelephu	Potassium, Sulphur (200 mg/l), calcium, Fluoride, Zinc,	Skin hydration and enhancement of elastic tissues
Duenmang	Sulphur (100 mg/l), calcium, Fluride	Skin regeneration, anti-inflammatory, and bactericidal activities. Skin protection by improving natural defenses Skin regeneration, anti-inflammatory, and bactericidal activities.

Chemical parameters

The presence of several predominant ions can define a classification of multi-ion waters. The *Gasa tshachhu* fell into the category of bicarbonate water (600/mg/l) and *Gelephu tshachhus* as bicarbonate water (600mg/l) and Suphate water (200 mg/l). Given the abundance of trace elements, nearly all the *tshachhus* and *menchhus* could possibly results in many health benefits which is in align the traditional wisdom of Sowa Rigpa (Norbert et al, Anngrainny et al, Benbrahim et al, Khole et al).

However, a extremely high level of arsenic was present in all the ponds of *Gasa Tshachhu* and Jagay menchhu. *Dobji drupchhu, Drugyel Mnechhu, Kabesa chukhor menchhu, Kabesa Menchhu Karpo* and *Raling Menchhu* had slightly higher arsenic level. This is unusual in hot springs and hypothermal waters in other country

Microbial analysis

Gelephu Tshachhu and Bjagay Menchhu at Paro had highest amount of Thermotolerant coliform count indicating fecal contamination. This comparable to findings from another study reporting temperature as a microbe control agent (Sara et al). This is often associated with ill effects on human health (Anggrainy et al).

LIMITATION OF THE STUDY

1. The study is first of its kind and a single study in Bhutan
2. The results and findings in the report are based on samples collected between November and January, which may vary depending on the time, season and geographical locations
3. Two different approaches/forms were used for the data collection i.e. scientific and gSoba-Rigpa methods. Thus, the result and findings of each variable might vary based on the standard and principle.
4. From gSoba - Rigpa perspective, the data and findings may vary because individuals interpret and perceive the taste, colour, odour, turbidity, and mineral content of Tshachhus and Menchhus differently.

RECOMMENDATIONS

The following recommendations are emanated from the findings and learning experiences of this study.

1. Conduct study on public perceptions and social beliefs towards using Tsachu and Menchu
2. Conduct Study on diseases /health conditions cured by Tsachus and menchus.
3. Explore Role of Tsachuus and Menchus on developing eco-tourism programmes.
4. Conduct further in-depth study on individual Tsachhus and Menchhus as deemed appropriate.
5. Install Health advisory board in renown/most frequently visisted Tsachhus and Menchuus
6. Develop guidelines on protection and proper usage of Tsachus and Menchhus.
7. Initiate public awareness campaigns highlighting the findings, particularly the presence of arsenic and coliform.
8. Install proper sanitation infrastructure, such as toilets and shower rooms, at Tsachu and Menchu sites.
9. Develop information leaflets on the proper usage of Tsachus and Menchus.
10. Advise against drinking Tsachus and Menchus, regardless of mineral content, due to potential health risks.
11. Include health advisories on conditions such as epilepsy, eye diseases, and communicable diseases.

12. Sensitize caretakers of Tsachu and Menchu on communicable diseases, sanitation, and hygiene practices.
13. Issue a public notification at the earliest, as it is the mandate of the MoH, despite the report's late publication.
14. Conduct sensitization for Local Government, schools and communities on protection and proper usage of Tsachus and Menchus
15. The Department of Tourism to emphasize uniform signage and washroom facilities at Tsachu and Menchu sites.

CONCLUSIONS

The tshachhus and menchhus in Bhutan are rich in trace elements, contributing to their many health benefits. Dobji Drupchhu, in particular, is alkaline in nature, making it unique. Many people who drink it have reported relief from gastritis and stomach ulcers.

There are few critical information that must be given priority. Firstly, arsenic is found in high level in some of the Tshachhus in Bhutan. This is unique to Bhutan. Secondly, coliform microbes indicating faecal contamination of the tshachhus and menchhus. This needs to an urgent public health intervention as a greater number of people travel to such sites. Lastly, all the tshachhus are sulphate in nature and there is need to create risk awareness regarding the culture of drinking, cooking and inhalation.

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