Journal of Scientific Temper
Vol 9(3&4), July-Dec 2021, pp. 184-206

ARTICLE

Prevalence of waterborne diseases and drinking water quality in the tribal's areas of Garhwal Himalayas Uttarakhand, India: An awareness programme and mitigation approaches

D.P. UNIYAL*, SHAKUNTALA KHATRI, RAJENDRA DOBHAL, J.S. ASWAL, VIKAS CHANDER, PRASHANT SINGH AND VINAY SHANKAR SINHA#**

Uttarakhand State Council for Science and Technology
(Govt of Uttarakhand), Vigyan Dham, Jhajra, Dehradun
* (Corresponding Author) Email: dpuniyal.ucost@gmail.com
** Department of Chemistry, DAV (PG), College, Dehradun
#TERI School of Advanced Studies, New Delhi

ABSTRACT

The livelihood strategies of the tribal communities are diverse from other communities as the ecological surrounding area, population size, language, physical features and level of development vary in the scheduled tribe's categories. A tribal population in Uttarakhand resides in long Tarai and far-flung remote hilly regions, where livelihood and development are a matter of hardship. In fact, the basic health facilities, sensitization about quality drinking water and many more are in adequate. The tribe's areas are most neglected and highly vulnerable to diseases with a high degree of malnutrition, morbidity and mortality. Their misery is compounded by poverty, illiteracy, ignorance of the causes of diseases, hostile environment, poor sanitation, lack of safe drinking water and blind beliefs, etc. Water from the different sources is being polluted by different means such as domestic waste, weathering of rocks, anthropogenic activities and sewage effluents, etc., which affect the physicochemical and biological properties of water, which ultimately create havoc among the tribes by many water-borne diseases.

Keywords: Tribe population, Livelihood strategies, Drinking water quality, Health issues

Introduction

The tribal populations are varied from other communities in terms of their ecological surrounding area, livelihood strategies,

population size, language, physical features and level of development attained as well as nature of their living status[22]. The tribal populations are included in the scheduled tribe's category in the Indian constitution particularly in article 342, based on some specific criteria[3]. As per the census of 2011, the entire population of tribes in India is calculated around 84,326,240 which accounts for 8.3 % of the total population of the country[14].

Indian tribe communities are categorised into five major regional groups across the country on ecological, social, economic, administrative and ethnic aspects which covers; Himalayan region (North East Himalaya, Central Himalaya and North West Himalaya), middle region (Bihar, Jharkhand, Madhya Pradesh, Odisha and West Bengal), Western region (Dadra and Nagar Haveli, Goa, Gujrat, Maharashtra and Rajasthan), Southern region (Andhra Pradesh, Tamil Nadu, Karnataka and Kerala) and Island (Andaman and Nicobar island in the Bay of Bengal and Lakshadweep in the Arabian Sea).

Middle and western regions of the country with their respective states have the maximum populations of tribes in which the total Scheduled Tribe (ST) inhabitants (83.2%) belong from Madhya Pradesh, Jharkhand, Odisha, Chhattisgarh, West Bengal, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh and Karnataka. 15.3% scheduled tribe population is shared by the Himalayan States of Assam, Meghalaya, Nagaland, Jammu and Kashmir, Tripura, Mizoram, Manipur, Arunachal Pradesh, Tamil Nadu and (Bihar from the Central region). Only 1.5 % of the scheduled tribe population is shared by the remaining states and union territories of India[17]. There is a consensus that these scheduled tribes are the descendants of the aboriginal population in India[4].

Tribal Population of Uttarakhand

Particularly in Uttarakhand state, it has five notified Schedule Tribe's (ST) *viz*., Tharu, Jaunsari, Bhotia, Buksa and Raji, in which Tharu community accounts highest numbers of its inhabitants 33.4 % followed by Jaunsari (32.5 %), Buksa (18.3 %), (Bhotia (14.2 %), and Raji (0.2 %) respectively (Fig. 1 & 2). Most of the tribes populations in the state are predominantly

inadequate to remote areas, forested and foothills of Uttarakhand. These populations are close enough to nature for their survival and livelihood and have a vast knowledge of traditional culture and reservoir of Indigenous Knowledge. All 13 districts of the state, counts for the tribal populations and their habitat can be categorised in different geographical regions. Maximum number of the tribal population resides in the rural areas of Dehradun, Udham Singh Nagar, Pithoragarh, Chamoli, Uttarkashi, Pauri and Tehri Garhwal in Uttarakhand (Table 1).

Table 1: Distribution of Different Tribal Population in Uttarakhand[22]

Tribes	District	Eco-cultural zones
Tharu	Dehradun, Pauri, Nainital, Udham Singh Nagar	Garhwal and Kumaon
Busa	Dehradun, Haridwar, Pauri, Nainital, Udham Singh Nagar	Garhwal, Kumaon and Bhabar
Raji	Pithoragarh and Champawat	Kumaon
Jaunasari	Dehradun	Jaunsar-Bawar
Bhotia	Chamoli, Uttarkashi and Pithoragarh	Garhwal and Kumaon

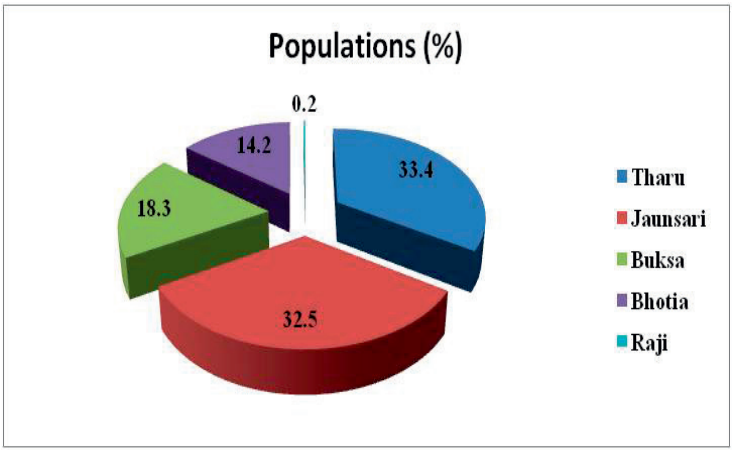

Fig. 1 Different communities of tribal population in terms of percentile in Uttarakhand[22]

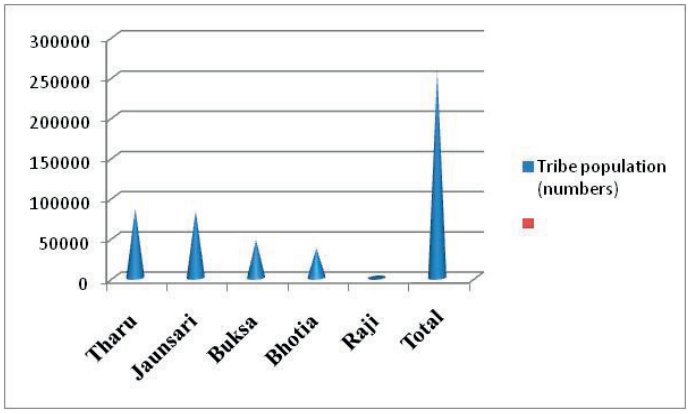

Fig. 2 Total numbers of different communities of tribal population in Uttarakhand[22]

In remote areas of ST communities in North West Himalaya of Uttarakhand, the supply of quality drinking water along with other health facilities are inadequate which directly, indirectly impact health conditions. Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity[33].

The health status of tribal populations is very poor and worst of primitive tribes because of the isolation, remoteness and being largely unaffected by the developmental process going on in India[15]. In the state of Uttarakhand, the main concentration of the tribal population is in the rural areas. Around 94.50 % of total tribal populations reside in rural areas and the remaining tribal population lives in nearby urban areas. The populations that reside in mountains are availing drinking water from their adjoining natural earthen sources and also have contaminations by plant debris, anthropogenic activities, leaf litters and seasonal disturbance which directly impact health conditions[9].

Besides, the other sources of water in the tribal areas are perennial or seasonal rivers, streams (of all sizes), springs and lakes. These serve more than 50 % of the total population of the region to meet their daily requirement[27]. It is a matter of fact that the water from the different sources is being polluted by different means such as domestic waste, weathering of rocks, anthropogenic activities, and sewage effluents, etc., which affect

the physico-chemical and biological properties of water, which are directly related to the drinking water quality[7&1], which resulted in many waterborne diseases[26].

Waterborne diseases and their impact on health

There is a wide range of water-borne diseases like diarrhoea, cholera, malaria, Japanese encephalitis, hepatitis, dengue, enteric fever, etc. Diarrhoea is one of the most common diseases in most of the states of India[13]. There were 8,501 thousand diarrhoea incidences in various states in 1998 which decreased to 8,414 thousand in 2006 with a fall of 1.02 per cent change[6]. India's under-five diarrhoea and pneumonia total deaths were counted approximately 2, 33,240 in 2017. In 2014, India launched the Integrated Action Plan for Prevention and Control of Pneumonia and Diarrhoea (IAPPD) to undertake collaborative efforts towards the prevention of diarrhoea and pneumonia-related[32].

Table 2: Main water-borne diseases and their causative agents as reported by medical practitioners during their lectures in tribal areas of Garhwal region, Uttarakhand

S. No.	Causative agents	Diseases
1	*Vibrio cholerae*	Cholera
2	*Salmonella typhi*	Typhoid fever
3	*Shigella dysenteriae*	Shigellosis
4	*Escherichia coli*	Diarrhea
5	*Salmonella etnterica*	Salmonelosis

In India, the total number of malaria cases were counted as over a million during 2015. However, in 2019 cases were reduced to around 338.5 thousand while as of June 2020, the numbers have been significantly low with approximately 62 thousand cases only in India. The water quality policies were successful in bringing down the malaria incidences by 7.8 per cent[34]. The decreased risk of infection like malaria is also associated with the improved sanitation and drinking water conditions reported by a survey-based study conducted in sub-Saharan Africa[11,12&35]. Hepatitis is also one of a water related diseases. Type A and E of hepatitis are mainly caused by the ingestion of contaminated food and water[16]. It was reported that there were 140 thousand incidences of hepatitis in 2000-01,

which fell to 129 thousand in 2006. As per WHO report in India, about 2,50,000 people die of viral hepatitis or its sequence every year[34].

Contaminated water is the root cause of waterborne disease due to the presence of pathogenic microorganisms in the polluted water[21]. Microbial contamination between the source and point of consumption is widespread; this can be due to contamination of water during collection, supply and storage[20]. Majority of water-borne diseases worldwide mainly affect children due to poor hygiene and sensitive immunity. Most of these diseases are life-threatening[5]. Number of diseases could be prevented, especially in developing countries, through access to improved water sources[24].

Water quality management and the availability of drinking water have a far-reaching impact on the human world. It is marked that rivers, springs and streams are the principal source of water (93 per cent) of the mountain states[31]. Uttarakhand has special importance among all the states of India as it provides drinking water to other states from its perennial rivers Ganga and Yamuna. In the past decade, human population, urbanisation, agricultural and industrial practices have rapidly increased, which are contaminating the water resources of the mountainous state[29].

Most of the drinking water sources of Uttarakhand are surface water sources, which are directly exposed to point sources of pollution such as septic tanks, domestic and farming wastes, as well as to soil with high humus content[30]. In the Kumaon region, about 97 % and 88 % of raw water sources were contaminated due to total coliform and faecal contamination bacteria[25]. The report of bacteriological monitoring of raw and supply water sources of all districts of Uttarakhand concludes that the water quality status of natural raw water sources like gadheras, rivers and springs, etc. requires regular monitoring in Garhwal as well as Kumaun region[29].

Around 80 % of illnesses and deaths are related to water-borne diseases like cholera, hepatitis A, typhoid and dysentery as the most dangerous diseases in India[2]. A 2019 joint report of WHO and UNICEF had pointed out that globally, one in four

healthcare facilities lacked basic water servicing and one in five had no sanitation services and 42 per cent had no hygiene facilities at the point of care. A WHO document on WASH in healthcare facilities points out that 8,27,000 people in low and middle-income countries die as a result of inadequate water, sanitation and hygiene every year. Also, the death of 2,97,000 children under five years can be prevented each year if better WASH could be provided. Addressing gaps in WASH across the Indian Health Care system is not only within the realm of possibility in terms of affordability but can also be combined with other national efforts to address health priorities[28].

The health care services and challenges in rural and tribal areas are a complicated phenomenon such as the concept of health and diseases are rather traditional, which results in their not seeking treatment at an early stage, frequent refusal of preventive measures and their ideas of medical care, lack of motivation of people for availing medical care at the initial stage of the disease, limited paying capacity or habit of getting treated always by traditional ways.

This study was supported by the National Science Academy (NASI), Prayagraj India, under the sub-tribal scheme (WASH). The study aimed to sensitize the tribal masses of the Garhwal region about Water, Sanitation, Health and Hygiene (WASH) and its importance in their life. This study not only imparts the baseline data but certainly play an important role in farming/improving the policies related to drinking water quality, its impact on health and natural resources in far-flung tribal areas of Uttarakhand.

In this paper an attempt has been made to understand the drinking water supply, water-borne diseases and sensitivity of tribes about natural resources, health and hygiene, thus, this study has academic and applied values.

Approach and Methodology

In this present study, awareness programmes were designed and organised on drinking water quality and its impact on health and sanitation (WASH) in the tribe's inhabitation of the Garhwal region. Three workshops cum hands-on activities were organised

in Govt Inter College, Dunda, Uttarkashi, Govt Inter College, Mana-Ghingharan, Gopeshwar, District, Chamoli and Eklavya Adarsh Residential School, Kalsi, District Dehradun, respectively. During the programmes, drinking water quality in tribal areas of Garhwal region was assessed by using a portable kit and the impact of drinking water quality in health conditions (mainly water-borne diseases) of tribal Masses of Garhwal Region, Uttarakhand (table 2). The methodology followed for the workshops is depicted in Fig 3.

Methodology

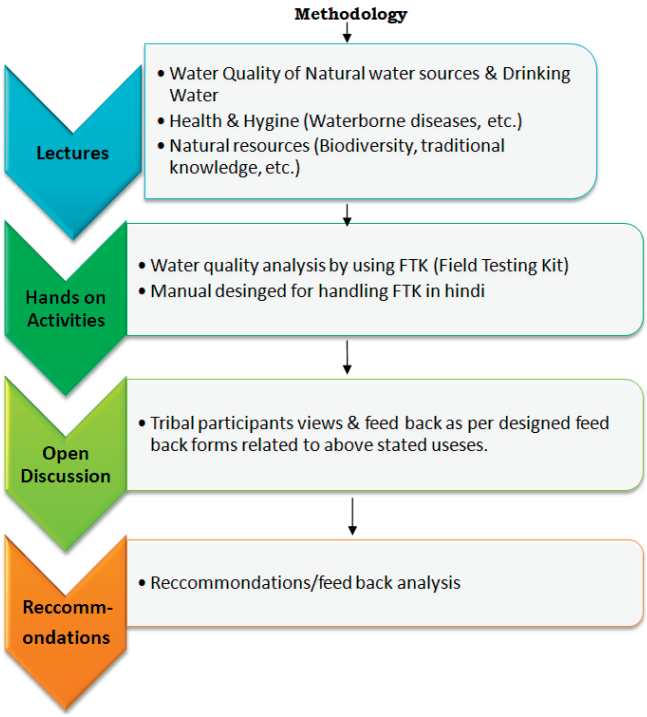

Fig 3. Methodology followed in the present study

Lectures were delivered by the subject experts including Medical practitioner from Uttarakhand Health Department, (dealing with health and hygiene), Engineers from Uttarakhand Jal Sansthan, (dealing with water resources) and Scientists

working on water-related issues from Uttarakhand State Council for Science and Technology, Dehradun, DAV (PG), College Dehradun and TERI, School of Advanced Studies, New Delhi.

All the participants in each programme were categorised into seven age groups i.e. under 17, 18-24, 25-34, 35-44, 45-54, 55-64, and above 65. Each age group were further categorised gender wise (male and female). The questionnaire and feedback form were developed as per specific locations consisting the information's about water supply in their houses, source of water (earthen/traditional/tape), the prevalence of water-borne diseases generally occurred in their areas, availability of medical facilities, knowledge about quality drinking water, etc. Being a resident of far-flung remote tribal areas many Vaidhys have been also practising traditional herbs to cure and prevent water-borne diseases. Therefore, a questionnaire was also developed for the documentation of medicinal herbs used in tribal areas. All the questionnaire and feedback forms were analysed, gender and age group wise.

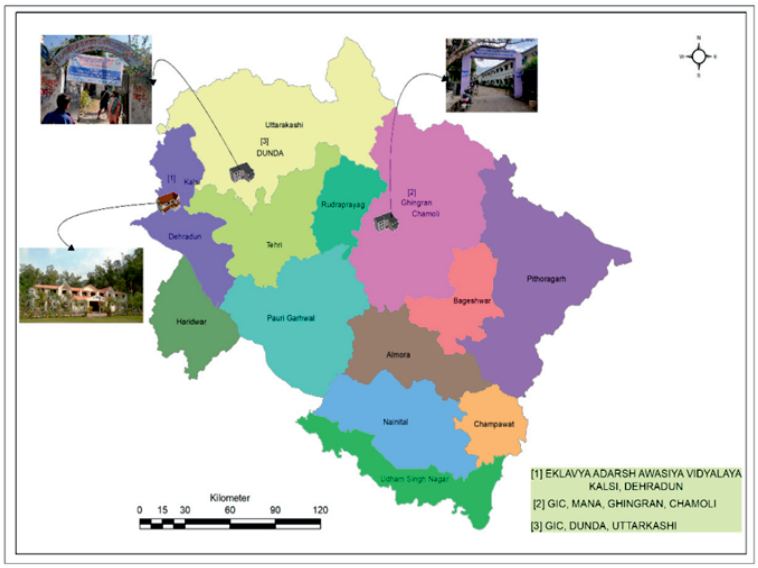

Fig 4. Map of the study area

Observations

The study was executed in the tribal areas of the Garhwal region, Uttarakhand under the joint aegis of The National Academy of Sciences, India (NASI), Prayagraj, and Uttarakhand State Council for Science and Technology (UCOST), Dehradun. The first awareness programme on 'Drinking water quality and associated health effects for local tribes of Uttarakhand' was organised for the tribal inhabitants (including all age groups) of Garhwal, Uttarakhand, in the Govt Inter College, Dunda, Uttarkashi, followed by the second awareness programme which was held at the Govt Inter College, Mana-Ghingharan, Gopeshwar District Chamoli and the third awareness programme at the Eklavya Adarsh Residential School, Kalsi, District Dehradun.

Total 552 tribal participants attended the programme in all three districts; of which 181 (81 male, 100 female) participated in district Uttarakhashi, 244 (74 male, 170 female) in district Chamoli and 127 (70 male, 57 female) in district Dehradun (Table.4). The participant represents Tharu, Busa, Khasa and Bhotia tribal communities of Uttarakhand state (Table 1 and Figure 1 & 2).

Scientific discussions were also held on local problems with the tribal population during the workshop, regarding the water quality, water supply, water-borne diseases, water sources and natural resources. Out of the total 552 tribal participants, only 56 respondents responded to the feedback, of which 24 in Kalsi, District Dehradun, 16 in Dunda, Uttarkashi and 23 in Gopeshwar District Chamoli (table-5).

The feedback forms of the respondents were subcategorised under different age groups under 17, 18-24, 25-34, 35-44, 45-54, 55-64 and 64 over in which 15, 8, 7, 17, 11, 2 and 3 were received respectively in all the three districts (Table 6). Based on the questioner and feedback of respondents who participated in all three workshops, it was observed that an increase in unplanned built-up and urban development in the region and change in the forest cover emerged as the responsible factors causing climate change which indirectly affected the natural resources (biodiversity, water & traditional knowledge).

The findings from the feedback analysis also recognised that the tribal inhabitants in remote areas of hills, especially women,

native people and marginalized communities are highly vulnerable to climate change. The tribal demanded to carry out Research & Development projects on above stated issue, so that mitigation measures can be taken to combat the climate change related issues. In all three workshops, the tribal community stressed and demanded extensive technological intervention for agriculture, horticulture, health & education and should be replicated in all the tribal areas of Uttarakhand.

Fig. 5 Participation of Tribal Communities representation in Awareness Programme

The session was categorised into the inaugural session; expert lectures; Capacity building through demonstration and Training of Field Testing Kit (FTK), open discussion and distribution of FTK to representatives of local ethnic communities & educational institutions. The physic-chemical properties of drinking water as per BSI limit turbidity, pH, total chloride, nitrate, iron, total hardness, chloride, total alkalinity, fluoride, and total coil form, etc. were also discussed. (Table 7).

Table 3: Details of Participation of tribes in three workshops

S. No.	Venue of the programme	Targeted tribal populations	Participated tribal populations
1	Govt Inter College, Dunda, Uttarkashi	100	181
2	Govt Inter College, Mana-Ghingharan, Gopeshwar District Chamoli	100	244
3	Eklavya Adarsh Residential School, Kalsi, District Dehradun	100	127
	Total	300	552

Table 4: Data details of Gender and Age Groups of all the Participants of the 3 main Workshops

S. No.	Venue of Workshop	Date of Workshop	Total no. of participants (Beneficiaries)		Age group (In Years)	
			Male	Female	Male	Female
1	Dunda, Uttarkashi	01/11/2019	81	100	15-65	14-60
2	Gopeshwar, Chamoli	03/11/2019	74	170	14-65	15-65
3	Kalsi, Dehradun	08/11/2019	70	57	15-60	15-55

Table 5: Number of respondents surveyed

Gender	Kalsi, Dehradun	Dunda, Uttarkashi	Gopeshwar, Chamoli
Male	18	8	8
Female	6	8	15
Total respondents (56)	24	16	23

Table 6: Age distribution of survey respondents

Age Groups	Kalsi, Dehradun	Dunda, Uttarkashi	Gopeshwar, Chamoli
Under 17	**14**	**1**	**-**
18-24	**3**	**3**	**2**
25-34	**-**	**1**	**6**
35-44	**5**	**5**	**7**
45-54	**2**	**5**	**4**
55-64	**-**	**-**	**2**
65 and over	**-**	**1**	**2**

Table 7: Standard Limit of Water Quality Parameters as per BIS Norms

S. No.	Parameters (IS:10500)	Unit	Standard IS:10500	
Essential			**Desirable**	**Permissible**
1	pH	-	6.5 – 8.5	NR
2	Total Hardness (as $CaCO_3$)	mg/L	300	600
3	Iron (as Fe)	mg/L	0.3	1.0
4	Chloride (as Cl)	mg/L	250	1000
5	Fluoride (as F)	mg/L	1.0	1.5
Desirable				
6	Dissolved Solids (TDS)	mg/L	500	2000
7	Sulphate (as SO_4)	mg/L	200	400
8	Nitrate (as NO_3)	mg/L	45	NR
9	Total Coliform	MPN/ 100 mL	10	NR
10	Total Residual Chlorine	mg/L	0.2	-
11	Turbidity	NTU	1	5

There is an utmost urgent requirement to ensure the quality of drinking water, its distribution and use through better water management. This meet also discussed proper sanitization practices like the correct way to wash hands before meals, after meals, and after disposal of faeces, which has resulted in 33% reduction in Diarrhea[23].

A WHO document on WASH in healthcare facilities points out that 8,27,000 people in low and middle-income countries died as a result of inadequate water, sanitation and hygiene each year[19]. Death of 2,97,000 children under five years can be prevented each year if better WASH (water, sanitation and hygiene) could be provided, Gaps in WASH across the Indian healthcare system is not only within the realm of possibility in terms of affordability but can also be combined with other national efforts to address health priorities[18].

Capacity building through demonstration and Training of Field Testing Kit (FTK) and distribution of FTK to representatives of local ethnic communities & educational institutions were also done in the present meet. A field testing kit has been prepared for field testing of 10 water quality parameters namely, pH, turbidity, hardness, nitrate, chloride, residual free chlorine, iron, and total coli form[8]. Besides, manual was also developed in Hindi for analysing water quality, so that tribal masses can handle Water Quality Testing Kit (WQTF) themselves.

Under the current NASI-UCOST project/programme, with the help of partner institutions, two (02) new parameters namely, fluoride and alkalinity, have been developed and added to the FTK, thus designing and improving the kit to the semi-quantitative test of a total of ten (10) water quality parameters. The usefulness of FTK will prove to be a milestone in self-water quality testing for the tribal people living in the mountainous areas.

Under the programme, total nine (09) FTKs were handed over to the volunteers for examination of drinking water sources and water bodies of their areas and nearby tribal areas to safeguard tribal students of their campus as well as local communities[9] (Figure 6). The Council regularly organises various science-based campaigns to sensitize the school, college students and researchers and masses to understand the basics of science and technology used in daily life activities and make them aware of the importance of science[10]. During the study, other sustainable sources for drinking water supply River Bank Filtration (RBF) and its water quality was also discussed[30].

Fig. 5 Distribution of FTKs in Tribal Communities A: Kalsi, Dehradun; B: Gopeshwar, Chamoli; C: Dunda, Uttarakhashi

Traditional Knowledge

Being a resident of far-flung areas tribal communities have lots of traditional knowledge to treat various water-borne diseases by their traditional medicinal herbs occurred in their adjoining areas. Medicinal herbs and their derivatives have been practised by Vadiyas (traditional healers) since time immemorable to cure various water-borne diseases. Therefore, it is very important to

document this rich traditional knowledge, so that scientific analysis can be made to validate their traditional knowledge for the betterment of humankind.

Table. 8: Major herbs used by the Traditional Vaidyas to treat water-borne diseases in the tribal areas
(as reported by tribal practitioner during the open discussion)

S. No.	Scientific Name of Plant	Vernacular name	Diseases
1	*Zingiber officinale*	Adrak	Malaria
2	*Argemone mexicana* L.	Pili Katili	Jaundice
3	*Boerhavia diffusa* L	Santi ghass	Dysentery, Diarrhoea
4	*Centella asiatica*(L.)	Birmi, Brahmi	Diarrhea, Cholera
5	*Haldina cordifolia*	Haldu	Jaundice
6	*Momordica charantia* L	Karela	Jaundice
7	*Cynodon dactylon*	Dubghass	Jaundice, Dysentery Diarrhoea
8	*Mimosa pudica*	Sharmili, Chui-mui	Dysentery
9	*Ocimum tenuiflorum*	Tulsi	Diarrhoea
10	*Berberies asiatica*	Kilmori	Dysentery, Diarrhea, Jaundice

Being a rich traditional knowledge community, cultural displays were also presented by the tribal communities, in which there was a clear cut message to protect and conserve natural resources and cultural values, so tribal people have a deep understanding of nature which they possess from generation to generations. These cultural practices need to be protected, documented for the betterment of the human race.

Conclusion

During all three workshops organised in the tribal areas of the Garhwal region of Uttarakhand in which total of 552 tribal peoples participated. From these workshops, it may be concluded that the drinking water sources specific in the mountainous region are more vulnerable due to climate change, which is the ultimate cause of water-borne diseases. There is an utmost urgent need to sensitize the tribal masses for mitigating climate change, drinking water quality and its impact on health conditions.

Acknowledgement

The authors are highly thankful to The National Academy of Sciences, India (NASI), Prayagraj, for financial support. We are thankful to Prof. Manju Sharma, Former Secretary; Department of Biotechnology (Govt of India) Past President and Chairman of Tribal programme, NASI Prayagraj for continuous guidance. We are also thankful to Dr Neeraj Kumar, Executive Secretary, NASI and Dr Santosh Shukla, Assistant Executive Secretary, NASI, Paryahraj for active support. The authors also reciprocate our gratitude to the officers and staff members of UCOST who have been associated with project execution. We are also thankful to the concerned Schools Principal and Teachers for providing the venue and local tribal inhabitants of concerned districts for their valuable feedback and sincere participation.

References

1 Alam J B, Hossain A, Khan S K, Banik B K and Islam M R (2007). Deterioration of water quality of Surma River, *Environmental Monitoring and Assessment,* 134,pp. 233–242.

2 Anonymous (2010). WHO & UNICEF Joint monitoring programme for water supply and sanitation (JMP), progress on drinking water and sanitation: Special focus on sanitation.

3 Balgir R S (2004). Health care strategies, genetic load, and prevention of haemoglobin opathies in tribal communities in India, *South Asian Anthropology,* 4, pp.189-198.

4 Bhasin M K and Walter H (2001). Genetics of castes and tribes of India, Delhi: Kamla-Raj Enterprises, pp. 26-78.

5 Borchardt M A, Chyou P H, DeVries E O & Belongia E A (2003). Septic system density and infectious diarrhea in a defined population of children, *Environment and Health Perspective*, 111, pp.742–748.

6 Bryce J (2005). WHO estimates of the causes of death in children. *Lancet,* 365, pp. 1147–52.

7 Chandra R, Singh S and Raj A (2006). Seasonal bacteriological analysis of Gola river water contaminated with pulp paper mill waste in Uttaranchal, India, *Environmental Monitoring and Assessment,* 118, pp. 393–406.

8 D. P. Uniyal, J.S. Aswal, Vikas Chander, Rajendra Dobhal, N. G. Srivastava and S Khadija Bari (2018). Drinking Water Quality Assessment in Schools of Garhwal Region Uttarakhand, India, *Journal of Environment and Bio-Sciences*, 32(1), pp.153-160.

9 D. P. Uniyal, Rajendra Dobhal, J. S. Aswal and Vikas Chander (2018) Report on Awareness programme on Drinking Water Quality and its

Impact on Health Condition in Tribal Inhabitants of Garhwal Region, Uttarakhand submitted to the NASI, Prayagraj, India pp.1-60.

10 D. P. Uniyal, Rajendra Dobhal, J. S. Aswal, Vikas Chander, Shakuntala Khatri, Brij Mohan Sharma and Jyoti Rajput (2020) Creating Scientific Temperament through Children's Science Congress in Uttarakhand, India, *Journal of Scientific Temper*, 8(3&4), pp. 146-160.

11 Eisenberg J N, Wade T J, Charles S, Vu M, Hubbard A, Wright CC, Levy D, Jensen P & Colford Jr J M (2002). Risk factors in HIV-associated diarrhoeal disease: the role of drinking water, medication and immune status, *Epidemiology Infection*, 128, pp.73–81.

12 Flegr J, Hoffmann R & and Dammann M (2015). Worse health status and higher incidence of health disorders in rhesus negative subjects, *Plos One*, 10, pp.1-14.

13 Gerald T and Keusch (2009). Diarrheal Diseases. Disease Control Priorities in Developing Countries, 2nd edition, Water, sanitation, and hygiene interventions to reduce diarrhea in less developed countries. *Lancet*; January 2005, Vol. 5.

14 Government of India Census data (2011. Population finder. *(http://www. censusindia.gov.in/PopulationFinder/Population_Finder. Aspx).*

15 Jain Y, Kataria R, Patil S, Kadam S and Kataria A (2015). Burden and pattern of illnesses among the tribal communities in central India: a report from a community health programme. *Indian Journal of Medical Research,* 141(5), pp.663–672.

16 Messner M, Shaw S, Regli S, Rotert K, Blank V. and Soller J (2006). An approach for developing a national estimate of waterborne disease due to drinking water and a national estimate model application, *Journal of Water Health*, 4, pp. 201–240.

17 Ministry of Tribal Affairs (2014). Socio-Economic, health and educational status of tribal communities of India, pp.34-50.

18 Mishra M (2012). Health status and diseases in tribal dominated villages of Central India, *Health Population and Perspectives,* 35, pp.157-175.

19 Morris R D and Levin R (1995). Estimating the incidence of waterborne infectious disease related to drinking water in the United States. *IAHS Publications-Series of Proceedings and Reports-Intern Assoc Hydrological Sciences*, 233,pp. 75–88.

20 Murphy H M, Pintar K D M, McBean E A, and Thomas M K (2014). A systematic review of waterborne disease burden methodologies from developed countries. *Journal of Water Health*, 12 (4)pp.634-655.

21 Pandey A, Agnihotri,V, Rai S, Tiwari A, Mukherjee S, Kumar K and Joshi R (2020). Annual report, Indicator bacteria in water monitoring. Monitoring and assessment of environmental parameters*.,* G.B. Pant National Institute of Himalayan Environment (An Autonomous Institute of Ministry of Environment, Forest & Climate Change, Govt. of India) Kosi-Katarmal, Almora 263 643, Uttarakhand, India, pp.1-152.

22 Pawar S, Chakraborty M, Mukherjee K and Das K (2017). Is Rh factor is behind the moderate life expectancy of Uttarakhand Tribals? A brief review, *Anthropol,* 5, pp.191.

23 Regina I Ejemot-Nwadiaro , John E Ehiri, Dachi Arikpo, Martin M Meremikwu, and Julia A Critchley (2015). Hand washing promotion for preventing diarrhea, *The Cochrane Library,* 3, (9):CD004265.

24 Rice G, Heberling M T, Rothermich M, Wright J M, Murphy P A, Craun M F and Craun G F (2006). The role of disease burden measures in future estimates of endemic waterborne disease. *Journal of Water Health*, 4 (Suppl. 2), pp.187–199.

25 Seth R, Mohan M, Singh P, Singh R, Dobhal R, Singh KP and Gupta S (2016). Water quality evaluation of Himalayan Rivers of Kumaun region, Uttarakhand, India, *Applied Water Science*, 6, pp. 137–147.

26 Sharma D and Kansal A (2011). Water quality analysis of River Yamuna using water quality index in the national capital territory, India, *Applied Water Science,* pp.147–157.

27 Singh A K and Rawat D S (1985). Depletion of oak forest threatening springs: a exploratory survey, *National Geographical Journal of India,* 31, (1), pp.44–48.

28 The Hindu English Daily News Paper (21st Feb., 2021) An estimate of WASH across health care facilities in India, pp.10.

29 Tyagi S, Singh P, Sharma B, Singh R, Dobhal R, Uniyal D P (2014). Bacteriological Assessment of Drinking Water Sources of Uttarakhand, India. *National Academy of Science Letters,* 38 (1), pp. 37–44.

30 Tyagi S, Dobhal R, Kimothi PC, Adlakha LK, Singh P, Uniyal DP (2013b) Studies of river water quality using river bank filtration in Uttarakhand India. *Water Quality and Exposure Health,* 5(3), pp.139–148.

31 Tyagi S, Sharma B, Singh P, Dobhal R (2013a). Water quality assessment in terms of water quality index. *American Journal of Water Resources* 1(3), pp.34–38.

32 Water-borne diseases in India (2013). *Omics Publishing Group*. Available at: *http://www.omicsgroup.co.in/water-borne-diseases/*.

33 WHO Guidelines for drinking-water quality (2008). World Health Organization, Geneva1. 4th edition.

34 WHO World Malaria report (2020). India continues to make Impressive Gains in reduction of Malaria Burden, *HFW/World Malaria Report/ 2ndDecember2020/1.*

35 Yang D, Yang He, Bo Wu, Yan Deng, Menglin Li, Qian Yang, Liting Huang, Yaming Cao, Yang Liu (2020). Drinking water and sanitation conditions are associated with the risk of malaria among children under five years old in sub-Saharan Africa: A logistic regression model analysis of national survey data. *Journal of Advanced Research*, 21, pp. 1-13.

Questionnaire

Local perspective: Biodiversity, traditional knowledge, Climate change and impact on springs/water resources

1. General Information:

Name		
Address		
District	Tehsil	
Gender	Male	Female
Age		
Working Area and Experience		
Department		
Detailed Address of Working Site	Village: Panchayat: Tehsil: District:	
How long have you been living in Uttarakhand (Hills)?		

2. Village level perceptions:

Size of land holding of Villagers under your working area	Below 1 ha	1- 2 ha	2 - 4ha	4 - 10 ha	Above 10 ha
Monthly Household Income of Villagers (in Rs.)	Less than Rs 5000	Rs 5000-10000	Rs 10,000-50,000	Above Rs 50,000	

3. Awareness on Climate Change and its Impact on Natural Resources (Biodiversity, traditional knowledge)

Do you find any change in rainfall?	YES NO
Since when are you experiencing the change	Last year Last five year Last 10 year More than 20 years
Do you think the timing of monsoon has changed? If yes, then by which month rain start nowadays.	YES NO Mention the Month _____

Do you think the amount of rainfall has changed over the years?	Increase Decrease No change
Do you think there is any change in number of rainy days?	Increase Decrease No change
Do you find any changes in the snowfall?	Increase Decrease No change
Do you feel any change in temperature due to climate change?	YES NO
During rainy season do you find any variation in the temperature?	Increase Decrease No change
Do you feel night temperature has increased during winter?	YES NO
Have you noticed any climate change awareness campaigns carried out in villages?	YES NO
Do you know how is climate change information disseminated in rural areas?	Pamphlets Radio Television Newspapers/magazines Town people
Do you feel that climate change awareness campaigns carried out at academic programme are sufficient?	YES NO
Do you know what the sources of irrigation water in rural areas are?	River Bore wells Tanks Canals Springs
Do you think road construction leads to disturbance of natural water resources?	YES NO
Have you observed any changes in the forested areas in recent times?	Increase Decrease No change
Do you think the amount of water in rivers and springs has changed?	ncrease Decrease No change
Did you find any change in agricultural productivity in recent years?	Increase Decrease No change

According to you, which are the two most important crops grown in your working area	Wheat Paddy Cotton Mustard Bajra Barley Any other_____
Do you feel that the time for sowing of seeds has changed due to climate change?	YES NO
Do you think there has been change in plant species due to climate change?	YES NO
Have you noticed that the selection of crops by farmers has changed due rainfall behaviour?	YES NO
Have you noticed that the farmers have shifted to less water consuming crops due to low rainfall?	YES NO
Have you noticed farmers are changing traditional irrigation practices to sprinkler and drip irrigation?	YES NO
Do you think farmers have crop insurance?	YES NO
Do you believe that women are less aware of new agriculture technology and extension?	YES NO
Do you think farmers have benefitted from any external support?	YES NO
hat form does the support come for farmers?	Financial support Material support Extension services Subsidized farm inputs Others_____
How often do the farmers receive this support?	Once a year Twice a year Once every two years Once every three years
Which organization offers support to help farmers?	Government agency Private institution Agricultural research organization NGO

4. Provide your opinion towards adaptation strategy

Suggest best practices to deal with floods	1. ---------- 2. ---------- 3. ----------
Suggest best practices to deal with droughts	1. ---------- 2. ---------- 3. ----------
Suggest alternative sources of drinking water in times of drought	1. ---------- 2. ---------- 3. ----------
Suggest how to make climate change awareness in rural areas	1. ---------- 2. ---------- 3. ----------
Suggest ways in which water bodies can be restored and stored	1. ---------- 2. ---------- 3. ----------
Suggest water harvesting techniques	1. ---------- 2. ---------- 3. ----------
Suggest ways to improve the ability of people to cope with climate change	1. ---------- 2. ---------- 3. ----------

5. Any other suggestions and remarks: