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Seasonal variations in sources of various Lift Water Supply Schemes of Bhoranj, District Hamirpur, Himachal Pradesh, by Assessing Water Quality Index.

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ABSTRACT
Water, a prime natural resource and its quality index is valuable to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment techniques to meet the concerned issue. Present study focuses on the water quality assessment of sources of lift water supply schemes i.e. Mallian Sadhrian Phase 1 and Aman Phase 2 of Tehsil Bhoranj, District Hamirpur, Himachal Pradesh using weighted arithmetic water quality index method, which was determined using different water quality parameters like pH, Dissolved Oxygen (DO), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Chlorides, Hardness due to Calcium (Ca) and Magnesium (Mg) and Water temperature. Present study revealed that the average WQI of source water is 61.44 which lie under poor category. It was recommended that source water should be properly treated before distribution for human consumption.

Keywords: Water quality index, Lift water supply schemes, quality parameters, irrigation, APHA, Bhoranj.

INTRODUCTION
Water is essence of life, it is a vital component that sustains our earth and all living organisms. Water is clear and odorless liquid that covers 70% of Earth's surface in form of ice and liquid. Out of which only 3% of water is fresh and drinkable, making it a most valuable substance on our planet. Water plays an important role in regulating the Earth's temperature, maintaining weather patterns and facilitates the growth of living organisms. It is also very important for animal survival because without water no one can live because water is life for us. But due to increase in manmade pollution most of the water resources are continuously depleting, which is affecting the ecological system of water bodies. Due to increased pollution water quality is also reducing and it is very crucial to identify the water quality of sources from where the water is being used. Water has various practical uses like drinking, sanitation, agricultural, industrial and house hold uses making it a single resource which deserves our attention, conservation and protection. [1,2]

Assessing the water quality of a particular area or source involves evaluating physical, chemical, and biological parameters [3]. Exceeding defined limits for these parameters can be harmful to human consumption, so the suitability of water for human consumption is often determined using the Water Quality Index (WQI) [2], which is a highly effective method for evaluating water quality.WQI has the potential to shrink the mass data into a single value to express the data in a simple and logical manner [4]. In this research an attempt has been made to identify the water quality index of various sources from where the drinking water is provided to water users and a comparative seasonal variation study of resource water has been done by assessing various water quality parameters.

Evaluation of water quality and geochemical characteristics of surface water from Tawang India was done by Gaur Nisha et al. during winter season by collecting 31 samples from various sites resulting 61% samples were in the range of less than 50 which was safe for drinking and 39% were categorized unsafe for drinking [5]. Similarly water quality index of Kunah stream of Hamirpur (H.P.) was also identified by Sharma Shivali et al. by assessing

the upstream and downstream data of the stream, the WQI index ranges between 61 upstream and 50 downstream showing upstream water is unsafe for drinking and overall stream water is unsafe for drinking without treatment [1]. The methods of evaluation of water quality index were also reviewed by Uddin Md et al. as this model is very popular tool for evaluating the quality of surface and groundwater, the aggregation technique used in this model allow a researcher to summarize the extensive water quality data into a single value [6]. A water quality analysis of Beas River was done by Kumar Vinod et al. by assessing various water quality parameters from various sites of river [7].

AREA OF STUDY

The present study aimed at Bhoranj, a tehsil in District Hamirpur, Himachal Pradesh, India with the population of 81,986 located 31.644^0 N 76.642^0 E. Mainly the people here speak pahadi (Himachali) and Hindi. The average temperature of the study area is between 14 to 38 °C and monsoon season starts in July. The main source of drinking water in the study area other than natural resources is piped water which is provided by Irrigation and Public health department of H.P. Water from the various sources is lifted by lift water supply schemes present in study area and distributed to public after treatment.

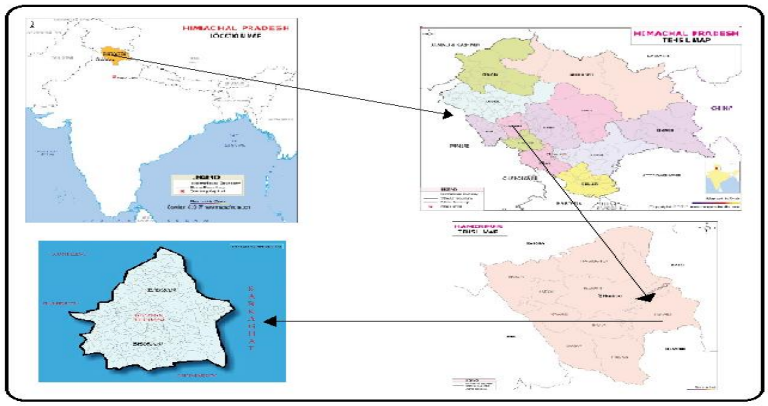

Fig. 1. Map of study area

MATERIALS AND METHODS

To assess the water quality index of various resource field visit of entire study area had been done to collect primary data. Various lift water supply schemes (LWSS) operating in the study area was identified to collected secondary data from government officials of irrigation and public health department. Two lift water supply schemes was identified and selected for the purpose of the research and water samples from the sources of selected schemes were collected on seasonal bases May 2023 to December 2023.

Each water sample collected was checked for various physico- chemical parameters like pH, DO, EC, TDS, TH, Chlorides, Hardness due to Ca and Mg and Water temperature. Parameters like pH, DO, TDS and temperature were measured on site with the help of digital meters [1] and for other parameters samples were safely transported to laboratory in 100ml sample bottles. All samples were analyzed in the laboratory as per APHA (1998). The mean value of various water quality parameters were placed in tabular form and water quality index is calculated mathematically using weighted arithmetic method of water quality index (WAWQI) given by Horton (1965) and standard values was compared using range of water quality index given in Table 1 Brown et al. (1972).

Table 1. Range of water quality index.

WQI Values	Water Quality
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
> 100	Unsafe for drinking

Source: Brown et al. (1972).

Water quality index is most effective way to describe all water quality parameters as a single component to express suitability of water resources for human consumption. Various mathematical calculations are used to determine the single value of water quality index.
The WQI using weighted arithmetic method was calculated using following equations:
Equation 1: Sub Index Water Quality Parameter (Qn)

$$Qn = \frac{Vn-Vo}{Sn-Vo} \times 100$$

Where (Vn) stands for observed actual value of any sample, (Sn) stands for permissible limit and (Vo) stand for ideal value of the parameters in pure water mainly (Vo = 0) except for pH and DO. (pH=7.0, DO=14.6mg/l)
Equation 2: Calculation of unit weight factor (Wn)

$$Wn = \frac{K}{Sn}$$

Where (K) is proportionality constant which is further calculated by:

$$K = \frac{1}{\Sigma\,(1/Sn)}$$

$$\sum \frac{1}{Sn} = \frac{1}{S1} + \frac{1}{S2} + \frac{1}{S3} + \cdots \ldots \ldots \ldots + \frac{1}{Sn}$$

(Sn) stands for derived value of the n^{th} parameter.
After calculating equation 1 and 2 the Water quality index (WQI) is calculated using equation 3
Equation 3: calculation of WQI

$$WQI = \frac{\sum(Qn \times Wn)}{\sum(Wn)}$$

RESULTS AND DISCUSSIONS

Table 2. showing LWSS, total number of panchayats served and population affected which was reported through the field survey of study area. Nine physico – chemical parameters like pH, DO, EC, TDS, TH, Chlorides, Hardness due to Ca and Mg and Water temperature were taken to analyze the water quality of the source. Seasonal mean and range value of these parameters were given in Table 3.

Table 2. Selected lift water supply schemes.

Sr. No	Name of LWSS	Connected Panchayats	Population Affected	Water Source
1	Maliyan Sadryan Phase – 1	03	7,096	Kunah Stream
2	Amman Phase – 2	03	5,445	Kunah Stream

It was reported from survey that total number of 6 panchayats were served by these two LWSS and population of 12,541 was benefited. Both of the schemes were fed by similar water source which is Kunah stream. Kunah stream is one of the major stream of tehsil

Bhoranj which originates from Bagwada near Awahdevi and joins with River Beas at Vilkeshwar, Hamirpur (HP) after covering about 48 kms.

Table 3. Seasonal mean and range of parameters for Physico – chemical properties of the source.

Parameter	May 2023	August 2023	December 2023
pH	7.73 (7.14-9)	7.69 (7.11-8.9)	7.36 (7.12-7.55)
DO (Dissolved Oxygen) (mg/l)	6.73 (6.1-8.1)	7.28 (6.1-8.1)	7.37 (6.1-8.9)
EC (Electrical Conductivity) (µS/cm)	92.7 (85-100)	93.1 (84-98)	85.8 (71-101)
TDS (Total Dissolved Solids)	122.4 (108-148)	103.9 (98-111)	117.6 (114-120)
TH (Total Hardness) (mg/l)	101.2 (92.78-109.5)	111.47 (110.49-112.89)	117.23 (117.22-117.33)
Chlorides (mg/l)	22.6 (10-35)	18.24 (9.9-29)	21.5 (10-35)
Harness due to calcium (Ca) (mg/l)	75.6 (64-86)	95.4 (94-100)	87.2 (64-100)
Harness due to Magnesium (Mg) (mg/l)	12.66 (12.36-12.88)	12.22 (11.21-14.02)	11.69 (10.05-12.36)
Temperature	18.1 (18-19)	15.3 (15-16)	10.7 (10-11)

Calculations of WQI

The Source water was analyzed for various physcio- chemical parameters and seasonal variation of water quality index was reported. Samples were collected during three different seasons i.e. summers (May), monsoon (August) and winters (December). Reported season vise calculated data of results is tabulated in Table 7. The water quality values for summers is 66.21 (Table 4), for monsoon 62.99 (Table 5) and for winters 55.13 (Table 6). All these values lie within the range of 51 – 75. The average water quality index of the source was 61.44 which indicated the water quality of the source was poor according to Brown et al. (1972) study. Table 7 indicated that the water quality index value is decreasing as the temperature is decreasing which means water quality of the source is improved in winters as compared to summers but still lies in the poor category.

Table 4. Depiction of water quality index of scheme's source in May 2023

Parameter	Standard values as per BIS (Sn)	1/Sn	$K = \frac{1}{\sum \frac{1}{Sn}}$	Wn = K/Sn	Vo	Vn	$Qn = \frac{Vn - Vo}{Sn - V} X100$	Wn x Qn
pH	8.5	0.117647059	2.640981824	0.310703	7	7.73	48.66666667	15.12091554
TDS	500	0.002	2.640981824	0.005282	0	122.4	24.48	0.1293024
Conductivity	300	0.003333333	2.640981824	0.008803	0	92.7	30.9	0.272021128
Total Hardness	200	0.005	2.640981824	0.013204	0	101.2	50.6	0.668168401
DO	5	0.2	2.640981824	0.528196	14	6.73	80.77777778	42.66652858
Magnesium (Mg)	30	0.033333333	2.640981824	0.088032	0	12.66	42.2	3.714981099
Calcium (Ca)	75	0.013333333	2.640981824	0.035213	0	75.6	100.8	3.549479571
Chlorides	250	0.004	2.640981824	0.010563	0	22.6	9.04	0.095497903
		$\sum \frac{1}{Sn}$ 0.378647059		1				$WQI = \frac{\sum(Qn\ X\ Wn)}{\sum Wn}$ **66.21689469**

Table 5. Depiction of water quality index of scheme's source in August 2023

Parameter	Standard values as per BIS (Sn)	1/Sn	$K = \frac{1}{\sum \frac{1}{Sn}}$	Wn = K/Sn	Vo	Vn	$Qn = \frac{Vn - Vo}{Sn - V} X100$	WnQn
pH	8.5	0.117647059	2.640981824	0.310703	7	7.69	46	14.29237222
TDS	500	0.002	2.640981824	0.005282	0	103.9	20.78	0.109759205
Conductivity	300	0.003333333	2.640981824	0.008803	0	93.1	31.03333333	0.273194898
Total Hardness	200	0.005	2.640981824	0.013204	0	111.4	55.735	0.73597561
DO	5	0.2	2.640981824	0.528196	14	7.28	74.66666667	39.43866119
Magnesium (Mg)	30	0.033333333	2.640981824	0.088032	0	12.22	40.73333333	3.585866432
Calcium (Ca)	75	0.013333333	2.640981824	0.035213	0	95.4	127.2	4.479105173
Chlorides	250	0.004	2.640981824	0.010563	0	18.24	7.296	0.077074414
		$\sum \frac{1}{Sn}$ 0.378647059		1				$WQI = \frac{\sum(Qn\ X\ Wn)}{\sum Wn}$ **62.99200986**

Table 6. Depiction of water quality index of scheme's source in December 2023

Parameter	Standard values as per BIS (Sn)	1/Sn	$K = \frac{1}{\sum \frac{1}{Sn}}$	Wn = K/Sn	Vo	Vn	$Qn = \frac{Vn - Vo}{Sn - V} X100$	WnQn
pH	8.5	0.117647059	2.640981824	0.3107037	7	7.36	24	7.456889856
TDS	500	0.002	2.640981824	0.005282	0	117.6	23.52	0.124231785
Conductivity	300	0.003333333	2.640981824	0.0088033	0	85.8	28.6	0.251773601
Total Hardness	200	0.005	2.640981824	0.0132049	0	117.23	58.615	0.774005748
DO	5	0.2	2.640981824	0.5281964	14	7.37	73.66666667	38.91046554
Magnesium (Mg)	30	0.033333333	2.640981824	0.0880327	0	11.69	38.96666667	3.430341947
Calcium (Ca)	75	0.013333333	2.640981824	0.0352131	0	87.2	116.2666667	4.094108712
Chlorides	250	0.004	2.640981824	0.0105639	0	21.5	8.6	0.090849775
		$\sum \frac{1}{Sn}$		1				$WQI = \frac{\sum(Qn\ X\ Wn)}{\sum Wn}$
		0.378647059						**55.13266696**

Table 7. Seasonal variations in Water quality Index

Sr. No.	Season	Month of collection	WQI	Status
1	Summers	May	66.21689469	Poor
2	Monsoon	August	62.99200986	Poor
3	Winter	December	55.13266696	Poor
		Average :-	**61.44333333**	

CONCLUSION AND RECOMENDATIONS

The water supply schemes are crucial source of drinking water in the study area which is utilizing the surface and ground water resources to fulfill the water demand of people of the area. But the man made pollution activities are depleting the quality of water resources. It is clearly seen from the above study that the source water which is utilized by water supply schemes is poor and not fit for human consumption so it is recommended that the water should be properly treated before distributing, proper canalization of the source should be done and strict action should be taken against those who are polluting the water sources.

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