Assessment of drinking water quality was done by selecting Nine Government senior secondary schools of three blocks in Solan district of Himachal Pradesh. The water quality parameters such as physical, chemical and biological parameters of water samples were analyzed. The water quality parameters such as temperature, pH, EC, TDS, temperature, BOD and COD ranged from 18.3 to 21.2°C, 6.95 to 7.13, 0.24 to 0.51 dS m$^{-1}$, 107.90 to 194.02 mg l$^{-1}$, 0.69 to 2.26 mg l$^{-1}$ and 56.50 to 119.75 mg l$^{-1}$; trace elements (As, Cd, Zn, Pb, Cu, Mn and Ni) nil, 0.000 to 0.001 mg l$^{-1}$, 0.001 to 0.003 mg l$^{-1}$, 0.00 to 0.01 mg l$^{-1}$, 0.00 to 0.02 mg l$^{-1}$, 0.03 to 0.06 mg l$^{-1}$ and 0.00 to 0.02 mg l$^{-1}$ respectively and biological parameters like total coliform as 20.00 to 54.00 MPN ml$^{-1}$, which were within the permissible limits except Fe which ranged from 0.63 to 0.95 mg l$^{-1}$ was above the permissible limits. The water quality index of drinking water for nine schools was in the range of 25.80 to 36.38, which categorized as excellent.
agriculture wastes, industrial pollutants, particulate matter from construction activities, and waste from people littering. Polluted water is responsible for waterborne diseases. The trace elements in water also play harmful roles to health of living beings. The impurities present in natural water are, living impurities, organic impurities and waterborne microorganism. These necessitate the need to manage and use water more efficiently.

However, poor water quality continues to pose a major warning to human health worldwide. Globally, waterborne diseases cause thousands of deaths particularly children in developing countries. Water pollution has the main effect on children and causes many diseases like cholera, diarrhea, typhoid and dysentery.

The study aimed to assess the water quality supplied to the educational institutes of Solan district by evaluating the physico-chemical characteristics and bacteriological quality parameters expressed as water quality Index (WQI) which is best technique to provide information to policy makers by combining complex data and giving a score to express WQI.

Fig. 1.1: Study area

(Note: S1 = Government Senior Secondary School (GSSS) Girls, Solan, S2 = GSSS, Oachghat, S3 = GSSS, Shamror, S4 = GSSS, Salogra, S5 = GSSS, Kandaghat, S6 = Government Primary School, Waknaghat, S7 = Government Middle School Anhech, S8 = DAV School Kumarhatti, S9 = GSSS, Dharampur).

Materials and Methods

Three blocks and nine sites namely Solan, Kandaghat and Dharampur of Solan district of Himachal Pradesh were considered for the present study. Solan district is located between 30°30” and 31°50” N Latitude and 76°42” to 77°20” E Longitude (Fig 1). Acid washed plastic bottles of 1 L capacity as per standard procedure were used to collect water samples from selected schools during two seasons i.e., summer and winter with two replications. Drinking water samples were collected from running tap continuously for five minutes. The physical parameters such as colour, odour, temperature (°C) were recorded using standard...
procedures. The pH was measured by using pH meter (Model-1013 of EIA make), EC and TDS were determined by conductivity TDS meter (Model-1601 of EIA make) and expressed in dS m\(^{-1}\) and mg l\(^{-1}\) respectively. The BOD was determined by using 5 day BOD test based on 5210 B method.\(^8\) The COD was determined by oxidizing water sample with hot H\(_2\)SO\(_4\) solution of potassium chromate with silver sulphate as the catalyst. The water samples were digested at 148\(^\circ\)C in the pre-heated thermo-reactor (TR 320) for 2 hrs. Chloride was masked with mercury sulphate, the concentration of Cr\(^{3+}\) ions was then determined photometrically by using Spectroquant Pharo 300 (Merk make) expressed in mg l\(^{-1}\). The observed procedure was related to EPA 410.4 US Standard method 5220 D, and ISO 15705. The trace elements such as As, Cd, Pb, Fe, Mn, Cu, Ni and Zn were estimated by using standard kits and Inductively Coupled Plasma of Atomic Emission Spectroscopy-6300 DUO (ICAP-6300 Duo) and expressed as mg l\(^{-1}\).

The number of the coliform groups was estimated by performing standard procedure, carried out by the multiple tube dilution tests (presumptive test, confirmed test, or completed test) and followed by\(^8\) by the membrane filter technique.

### Results and Discussion

### Physical Parameters

The colour of tap water in selected educational institutes was colourless in all the selected locations. The odour of tap water in selected educational institutes was odourless in all the selected locations. The temperature of tap water ranged from 18.3 to 21.2\(^\circ\)C in selected educational institutes (Table 1). Among the seasons, the mean temperature was found higher (24.9\(^\circ\)C) in summer and lower (13.2\(^\circ\)C) in winter season. The temperature of drinking water in selected schools was within the prescribed limits of BIS. The results are conformity with the findings of Trivedi\(^3\) and Rana\(^9\) who observed maximum temperature in summer season.

### Table 1: Seasonal variation of Physical Parameters of tap water in selected Educational Institutes

| Schools | Colour         | Odour          | Temperature |
|---------|----------------|----------------|-------------|
| S1      | Colourless     | Odourless      | 12.3 24.5 18.4 |
| S2      | Colourless     | Odourless      | 12.6 25.5 19.0 |
| S3      | Colourless     | Odourless      | 14.9 27.6 21.2 |
| S4      | Colourless     | Odourless      | 12.3 24.3 18.3 |
| S5      | Colourless     | Odourless      | 13.8 23.3 18.5 |
| S6      | Colourless     | Odourless      | 12.6 25.6 19.1 |
| S7      | Colourless     | Odourless      | 14.8 24.5 19.6 |
| S8      | Colourless     | Odourless      | 12.6 24.9 18.7 |
| S9      | Colourless     | Odourless      | 13.2 23.9 18.6 |

### Chemical Parameters

The pH of water was in the range of 6.95 and 7.13 of tap water in all the selected locations. Among the seasons, the mean pH was found higher (7.07) in summer and lower (6.99) in winter season. The pH of drinking water was within the prescribed limits of BIS. The higher pH during summer seasons due to more evaporation and less dilution in comparison with other seasons.\(^10\) The EC of tap water was in the range of 0.24 and 0.51 dSm\(^{-1}\) in all the selected schools. Among the seasons, the mean EC was found higher (0.35dSm\(^{-1}\)) in summer and lower (0.32 dSm\(^{-1}\)) was in winter season. The EC of tap water in the schools was within the limits of WHO and similar to the findings of Jadhav.\(^11\)
The TDS of tap water was in the range of 107.90 and 194.02 mg l\(^{-1}\) in selected institutes. Among the seasons, the mean TDS was found higher (143.77 mg l\(^{-1}\)) in summer and lower (133.83 mg l\(^{-1}\)) in winter season. The TDS of tap water in selected schools was within the limits prescribed by BIS. The obtained trend is in confirmation with the findings of Sharma\(^1\) and Rao.\(^2\) The BOD of tap water was found to be between 0.69 and 2.26 mg l\(^{-1}\) in all the selected educational institutes. Among the seasons, the mean BOD was found higher (1.49 mg l\(^{-1}\)) in summer and lower (1.39 mg l\(^{-1}\)) in winter season. The BOD of tap water was within the limits prescribed by BIS. The results are similar to the findings of Trivedi\(^3\) and Mathur\(^4\) who have indicated enrichment of water sources with organic matter cause for high BOD. The COD of drinking water ranged between 56.50 and 119.75 mg l\(^{-1}\) in selected educational institutes. Among the seasons, the mean COD was found higher (98.16 mg l\(^{-1}\)) in summer and lower (82.50 mg l\(^{-1}\)) in winter season. The COD of drinking water was within the limits as per of BIS. The results are similar to the findings of Joseph\(^5\) and Chattopadhyay\(^6\) who also reported similar results where they found maximum COD in summer season. The results are summarized in Table 2.

### Heavy Metals

The concentration of As of tap water was found to be 0 mg l\(^{-1}\) in selected educational institutes and within the permissible limits as given by BIS. The concentration of Cd of tap water was in the range of 0.000 and 0.001 mg l\(^{-1}\) in selected educational institutes. Among the seasons, the mean Cd was found higher (0.001 mg l\(^{-1}\)) in summer and lower (0.000 mg l\(^{-1}\)) in winter season. The Cd of drinking water was within the prescribed limits of BIS. The results are similar to the findings of Lokeshwari\(^7\) who reported Cd in the sampled water much below the permissible levels. The concentration of Zn of tap water ranged from 0.001 to 0.003 mg l\(^{-1}\) in selected educational institutes. Among the seasons, the mean Zn was found higher (0.002 mg l\(^{-1}\)) in summer and (0.001 mg l\(^{-1}\)) in winter season. The concentration of Zn in drinking water in the schools was within the prescribed limits of BIS. The results are in confirmation of the findings of Shanbehzadeh\(^8\) that the concentration of Zn was within the standard range for drinking water. The Pb concentration of drinking water was in the range of 0.00 and 0.01 mg l\(^{-1}\) in selected educational institutes. Among the seasons, the mean Pb was found higher (0.01 mg l\(^{-1}\)) in summer and lower (0.000 mg l\(^{-1}\)) in winter season. The Pb of drinking water was within the prescribed limits of BIS. The results are within the findings of Wogu\(^9\) where Pb had the least mean content of 0.01 mg l\(^{-1}\). The concentration of Cu of tap water was in the range of 0.00 to 0.02 mg l\(^{-1}\) in selected educational institutes. Among the seasons, the mean Cu was found higher (0.01 mg l\(^{-1}\)) in summer and lower (0.00 mg l\(^{-1}\)) in winter season. The Cu of drinking water was within the prescribed limits of BIS. The results are similar to the findings of Shanbehzadeh\(^10\) who reported that the mean concentration of Cu was within the standard range for drinking water. The Fe concentration of tap water was in the range of 0.63 and 0.95 mg l\(^{-1}\) in selected educational institutes. Among the seasons, the mean Fe was found higher (0.88 mg l\(^{-1}\)) in summer and lower (0.75 mg l\(^{-1}\)) Fe in winter. The Fe of drinking water was above the prescribed limits of BIS because soil in Himachal Pradesh is considered to be rich in iron. The results are in conformity of the findings of Puri\(^11\) who found increase in Fe concentration during summer. The Mn concentration of tap water was in the range of 0.03 and 0.06 mg l\(^{-1}\) in selected educational institutes. Among the seasons, the mean Mn was found higher (0.05 mg l\(^{-1}\)) in summer and lower (0.04 mg l\(^{-1}\)) Mn in winter season. The Mn of drinking water was within the prescribed limits of BIS. The results are in conformity of the findings of dwivedi\(^12\) who found that the manganese content in water samples was below the prescribed limit. The Ni content of tap water was in the range of 0.00 and 0.02 mg l\(^{-1}\) in selected educational institutes. Among the seasons, the mean Ni was found higher (0.02 mg l\(^{-1}\)) in summer and lower (0.00 mg l\(^{-1}\)) Ni in winter season. The Ni content of tap water was within the prescribed limits of BIS. The results are similar to the findings of Lokeshwari\(^13\) where it was found that all the samples from various sources contain Ni much below the limits prescribed. The concentration of heavy metals has been presented in Table 3.

### Biological Parameters

The total coliform of tap water ranged from 20.00 to 54.00 MPN ml\(^{-1}\) in selected educational institutes.
(Table 4). Among the seasons, the mean total coliform was found higher (41.53 MPN ml$^{-1}$) in summer and lower (34.11 MPN ml$^{-1}$) total coliform in winter season. The total coliform of water was within the prescribed limits of BIS. The results are within the findings of Shaikh$^{23}$ who observed maximum concentration of total coliform in summer and minimum in winter.

Table 4: Seasonal variation of Biological Parameters of tap water in selected Educational Institutes

| Schools | Winter | Summer | Mean  |
|---------|--------|--------|-------|
| S1      | 25.00  | 33.00  | 29.00 |
| S2      | 39.00  | 58.00  | 48.50 |
| S3      | 52.00  | 34.00  | 43.00 |
| S4      | 34.00  | 36.00  | 35.25 |
| S5      | 19.00  | 21.00  | 20.00 |
| S6      | 35.00  | 57.00  | 46.00 |
| S7      | 21.00  | 26.00  | 23.50 |
| S8      | 34.00  | 52.00  | 43.25 |
| S9      | 52.00  | 56.00  | 54.00 |

Table 7: Water quality index in selected Educational Institutes

| Schools | WQI  |
|---------|------|
| 1       | S1   | 25.80 |
| 2       | S2   | 28.16 |
| 3       | S3   | 31.38 |
| 4       | S4   | 35.75 |
| 5       | S5   | 32.03 |
| 6       | S6   | 32.72 |
| 7       | S7   | 36.38 |
| 8       | S8   | 33.31 |
| 9       | S9   | 30.91 |

Correlation among Water Quality Parameters

The water quality parameters were correlated with each other significantly during winter. The pH was correlated negatively with chemical oxygen demand ($r = -0.86$, $p<0.01$) copper ($r = -0.68$, $p<0.05$). Akotoet$^{24}$ have reported similar results and total coliform ($r = -0.69$, $p<0.05$). The temperature has highly significant +ve correlation with nickel ($r=0.87$, $p<0.01$). The biological oxygen demand has significant -ve correlation with manganese ($r=0-0.71,p<0.05$). The Arsenic has highly significant and +ve correlation with copper ($r = 0.66$, $p<0.05$). Zinc has highly significant and +ve correlation with copper ($r = 0.70$, $p<0.05$) and iron ($r = 0.70$, $p<0.05$). Kar$^{25}$ have also reported similar results (Table 5).

The water quality parameters were correlated with each other significantly during summer. The pH showed significant positive correlation with electrical conductivity ($r = 0.725$, $p<0.05$) and chemical oxygen demand ($r = 0.686$, $p<0.05$). Tripathi$^{26}$ have reported similar findings. The biological oxygen demand showed significant and -ve correlation with manganese ($r = -0.672$, $p<0.05$). The chemical oxygen demand showed highly significant -ve correlation with nickel ($r = -0.83$, $p<0.01$). The arsenic showed significant and -ve correlation with iron ($r = -0.79$, $p<0.05$) and +ve with cadmium ($r = 0.060$) and lead ($r = 0.350$). Similar finding has been reported by Akotoet.$^{24}$ The cadmium showed significant and +ve correlation with manganese ($r=0.77$, $p<0.05$) presented in Table 6.

Water Quality Index (WQI)

The WQI ranged from 25.80 to 36.38 in selected educational institutes (Table 7). The WQI for all the selected educational institutes in Solan district categorized as excellent.

Conclusions

The study revealed that various water quality parameters of drinking water in selected educational institutes were found to be within the prescribed limits of BIS and WHO except iron (0.63 to 0.95 mg l$^{-1}$), which was above the limit. The(WQI) in selected schools was found to be excellent.

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Conflict of Interest
The authors do not have any conflict of interest.

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