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An Assessment of Water Quality of Nainital Springs, Uttarakhand, India

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Abstract: **Polluted water is wreaking havoc on humans and all other things on the planet. In the mountainous region, spring water is the primary supply of water for survival. The construction of road, settlement and other human activity are continuously increasing in upper catchment area in North West Himalayan region. It's a real important issue nowadays which are responsible for contamination and extinction of springs. This research aimed to determine the physico-chemical quality of Nainital surrounding springs water. Total eight sampling sites and nine water quality parameters were selected for analysis. As per findings the mean value of the pH was (6.94), Dissolved Oxygen (2.89 mg/l), Biological Oxygen Demand (0.83 mg/l), Total Dissolved Solid (11.29), Nitrate (0.54 mg/l), Calcium (105.97 mg/l), Manganese (0.07 mg/l), Zinc (0.02 mg/l) and Total Coliform (0.75, /100 ml of water). The spatial distribution map of all spring's water parameters was composed in ArcMap 10.2 using interpolation, kriging method. The current finding is following the BIS (Bureau of Indian Standard) and WHO (World Health Organization) acceptable and permissible limit. The total coliform concentration was showing contamination at site 1, 2, 4, 5 and 6. So, there is the need to manage, protect and minimize the human interference nearby these natural springs surrounding area to reduce the contamination and degradation of this precious resources by government involvement and local community awareness.**

Keywords**:** **Physico-chemical characteristics, Himalaya region, Nainital Spring, Kriging**

I. INTRODUCTION

Water contamination is a hot topic these days all around the world. India's natural freshwater, which is accessible to humans throughout the country viz. ponds, tanks, lakes, and reservoirs have all been continuously polluted. Due to rising human population growth, which leads to increased water use, as well as expected climate change, the future of sustainable water supply is questionable. Uttarakhand is a state of India in North West Himalayan region. It is a hotspot of freshwater resources. Holly River Ganga, Yamuna is the major river of Uttarakhand and numbers of small river are flowing within the state. The source of these river water is glacier and springs. India has 5 million springs, and almost 3 million of them are in the Indian Himalayan region (IHR) alone (NITI Aayog, 2017). Mountains springs are extremely important since they are the primary source of water for drinking and other domestic needs in the highland habitat (Agarwal et al., 2012; Jasrotia et al., 2018). In Himalayan region, natural sourceof groundwater is spring. They are commonly handled by the community and are not privately owned. The water qualities concerning physico-chemical properties of almost all springs nearby Nainital basin either within the acceptable or within the permissible limit (Maindoli et al., 2018). The quality of the spring water is good in but in summer months, it's scarce in Kumaon division of Uttarakhand state (Chhimwal et al., 2022). According to current estimations, the hydrosphere of the Earth contains a massive volume of water - roughly 1386 million cubic kilometers (Igor, 2000). The spring hydrograph, also known as the temporal discharge variation, is the only way to predict and regulate the spring's activity (Vashisht and Sharma, 2007). As a result of climate change and increased water consumption, water scarcity has become a global systemic challenge (Wegener et al., 2010). The freshwater shortage becoming more widely recognized as a worldwide systemic problem (Burek et al., 2016). The necessary primary resource of water availability is essential for socio-economic development and poverty alleviation. Water is an important primary resource, and the availability of this resource is a critical factor in both the expansion of the economy and the alleviation of poverty.

Because of this, ensuring adequate water supply has quickly become one of the most pressing concerns of the twenty first century (Srinivasan et al., 2017; Bhat et al., 2020). Because of the ever-increasing need for groundwater supplies, many rural regions in India are on the verge of experiencing a severe water shortage. This has led to the depletion and drying up of wells and springs in a great number of Indian villages (Rodell et al., 2009). According to conservative estimates, over 15 present of the world's population relies on freshwater springs located in mountainous region such as the Western Ghats, Himalayan Range, Eastern Ghats, Aravalli Range, and other similar mountain ranges for their household and livelihood requirements (Mongabay, 2019). Groundwater in the Doon valley area is governed on a regional scale by a number of factors including type of drainage system, geology of the area and geomorphology (Khali et al., 2020). The natural beauty, ecological benefits, and biological diversity are the key feature of Trans Himalayan region (Singh and Mishra, 2019; Ray et al., 2007).

Geographic information systems (GIS) interpolation technique are cutting-edge, multipurpose tools that can be applied to a wide range of environmental issues. Approaches from the field of geostatistics have been incorporated into the spatial interpolation and statistical methods. Using Geo Statistical Analysis Approach, GIS interpolation may forecast attribute values at un-sampled sites from point measurements (Nagalakshmi et al., 2016; Burrough et al., 1998). Spatial interpolation kriging is a useful methodological step in hydrology and other scientific disciplines (Rostami et al., 2019; Spokas et al., 2003).

Water is required for the survival of all living creatures in this world, including plants, animals, and microbes. Because of shifting weather conditions and patterns of precipitation, a significant number of communities, including hamlets, villages, and settlements, are in risk of running out of potable water in Indian Himalayan Region (Kiran, 2018). Groundwater and river water are India's primary sources of water for drinking, residential, and agricultural use; however, natural streams and springs offer huge water in some hilly region. The current study focused on nearby Nainital springs water quality analysis in Uttarakhand state of India.

II. MATERIALS AND METHOD

Study Area

In the Western Himalayas, the investigated springs are located between 1578 and 2135 meters above sea level (Fig 1 & 2). The area has a subtropical climate and is primarily covered with forest and human habitation. Every year, a huge number of tourists' flock to Nainital as the town grows in popularity and tourism infrastructure. The early portions of the spring season are marked by mild cold, while late spring serves as a transition between spring and summer. The monsoon season begins in late June and lasts until the middle of September. The monsoon months receive the majority of the rainfall (more than 80%). The Aesculus indica, Populus ciliate, Oak species and Cornus macrophylla plant species are distributed nearby hilly terrain of Nainital lake. Fig 3 and 4 presenting the temperature and precipitation status of the study area and their surroundings (Harris et al., 2020).

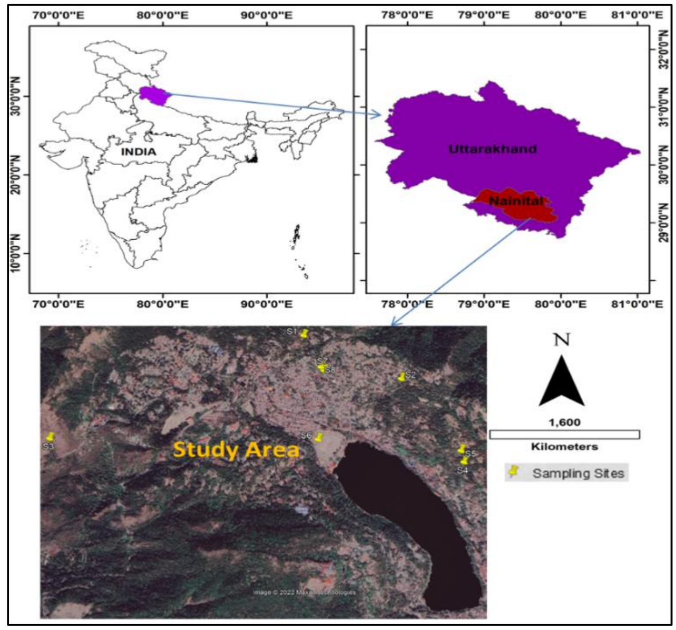


Fig 1. Location of study area

Fig 2. Springs, water testing and sampling

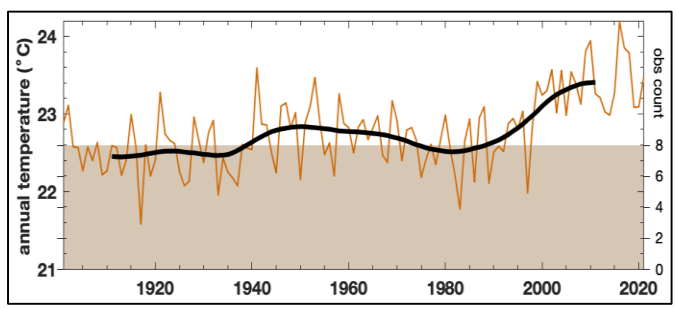


Fig 3. Annual temperature

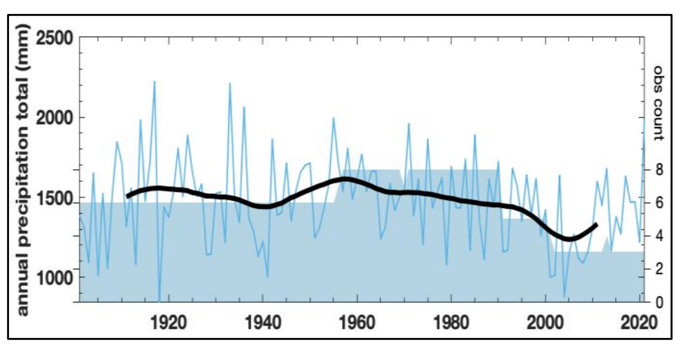


Fig 4. Annual precipitation

Methodology

Water samples were collected from 8 sample stations (Table 1). Samples were collected in clean glass bottles in February 2021. After proper labelling, the samples were taken to the lab to be analysed further for physicochemical characteristics. The sample was collected and preserved using standard techniques (American Public Health Association, 2005) and BSI (1991). Digital equipment was used to test physio-chemical variables like as pH, temperature, and electrical conductivity. Biological oxygen demand, chemical oxygen demand, nitrate, and phosphate were all measured according to the APHA (American Public Health Association) 2005 standard analytical techniques. The spring water quality data were interpolated and generated the water quality map in spatial form using kriging method in ArcGIS software. Kriging derives from regionalized parameter theory. It expresses spatial attribute variation as a variogram and reduces estimated prediction errors (Oliver and Webster, 1990).

TABLE 1

GPS locations of sampling sites at Nainital

Sampling Sites	Sites Name	Latitude	Longitude
S1	Near Nishant Hostel	29.398°	79.4526°
S2	Near Ramleela Ground	29.394783°	79.4592°
S3	Near Satyanarayan Tample	29.391167°	79.4355°
S4	Near Vimarsh Cottage	29.3891°	79.46305°
S5	Near Bhotiya Band	29.389867°	79.4629°
S6	Near Masjid	29.390757°	79.453429°
S7	Chuna Dhara (A)	29.39552°	79.453914°
S8	Chuna Dhara (B)	29.395691°	79.453746°

III. RESULTS AND DISCUSSION

An attempt has been made in this study to describe and analyse the spring characteristics accessible in and around the major town and their surrounding areas in Nainital. The average value of the physico-chemical analysis of spring water is shown inTable 2.

pH (Potential of hydrogen)

The pH scale runs from 0 to 14, and it is an important factor in determining the health of bodies of water. In current study, the pH readings fluctuate between 6.50 to 7.30 (Fig 5). Where the minimum pH value was recorded at Near Bhotiya Band (site 5, 6.5) and the maximum at Near Satyanarayan Tample (site 3, 7.30). The result of the pH experiment was matched with the observation (Maindoli et al., 2018). As a result, the spring waters are slightly acidic and slightly basic at different sampling stations. The spring water pH is affected by soil composition and bedrock of the surrounding topography. The water organism adopted their life in a specific pH. Keeping track of how pH changes over time is a key management tool (Sadovski, 2019).

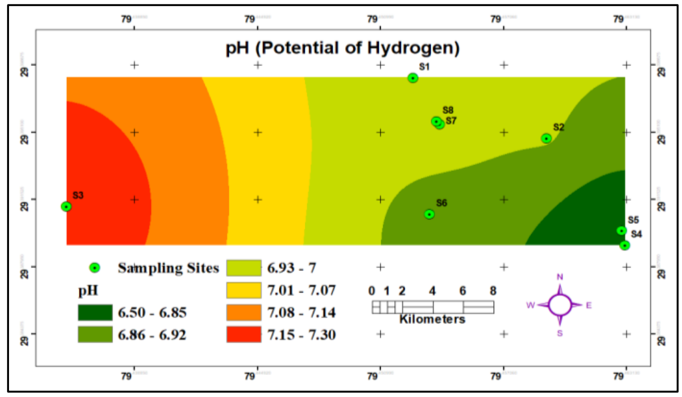


Fig 5. Spatial distribution map of pH

DO (Dissolved oxygen)

Plant photosynthesis raises DO, while chemical oxygen oxidation, nitrification, and plant transpiration reduce it (Jamalianzadeh et al., 2022). Temperature and salinity are two factors that influence DO (Ultsch & Nordlie, 2019). The presence of dissolved oxygen in aquatic ecosystem is an essential indicator of good water quality for determining the viability of aquatic life. Dissolved oxygen concentrations ranged between 2.06 mg/l to 3.18 mg/l (Fig 6). Where minimum DO was showing at Near Masjid (site 6, 2.06 mg/l) and at Near Ramleela Ground (site 2, 3.18 mg/l) showing maximum DO concentration of spring. The low DO level at site 6 may be due to organic and inorganic pollutant concentrations.

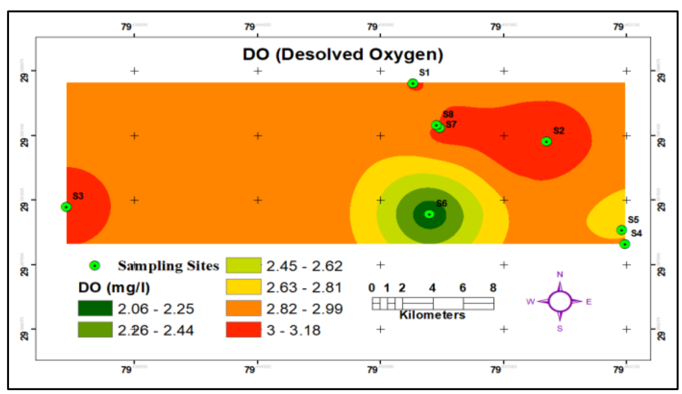


Fig 6. Spatial distribution map of DO

TABLE 2

Details of physico-chemical characteristics of spring water

Sampling Sites	Name if Sites	pH	DO (mg/l)	B.O.D. (mg/l)	T.D.S. (mg/l)	Nitrate (mg/l)	Ca (mg/l)	Mn (mg/l)	Zinc (mg/l)	Total coliform (MPN)
S1	Near Nishant Hostel	6.80	3.01	0.60	9.97	1.08	100.11	0.12	0.03	1
S2	Near Ramleela Ground	7.00	3.18	0.70	11.59	0.20	34.12	0.13	0.01	1
S3	Near Satyanarayan Tample	7.30	3.17	0.30	13.53	0.67	186.24	0.10	0.06	0
S4	Near Vimarsh Cottage	7.00	2.86	1.40	9.60	0.16	124.01	0.06	0.03	2
S5	Near Bhotiya Band	6.50	2.74	1.00	12.62	0.41	107.86	0.11	0.01	1
S6	Near Masjid	6.80	2.06	1.00	12.57	0.31	94.06	0.01	0.01	0
S7	Chuna Dhara (A)	7.00	3.12	0.40	11.00	0.47	100.61	0.03	0.02	0
S8	Chuna Dhara (B)	7.10	2.95	1.20	9.41	0.98	100.76	0.03	0.01	1
Min		6.50	2.06	0.30	9.41	0.16	34.12	0.01	0.01	0.00
Max		7.30	3.18	1.40	13.53	1.08	186.24	0.13	0.06	2.00
Mean		6.94	2.89	0.83	11.29	0.54	105.97	0.07	0.02	0.75
BIS (Acceptable limit)/*WHO specification		6.5 - 8.5		0.75*	500	45	75	0.1	5	0/100 ml*
Permissible limit (BIS and *WHO)		No Relaxation		1.5*	2000	No Relaxation	200	0.30	15.0	No Relaxation

BOD (Biological oxygen demand)

The term "biological oxygen demand," refers to the amount of oxygen that is typically required to breakdown organic matter found in the water (Daroini, 2020; USGS, 2020). The BOD values can be fluctuating due to variation in water temperature, as well as rise in photosynthetic activity in a water ecosystem. Organic pollution in the water is indicated by a high BOD level. The BOD observation varies from a 0.30 mg/l to 1.40 mg/l (Fig 7). The minimum BOD recorded at Near Satyanarayan Tample (site 3, 0.30 mg/l) and maximum at Near Vimarsh Cottage (site 4, 1.40 mg/l). According to WHO standards, the current results show good water quality in all springs on the basis of BOD concentration.

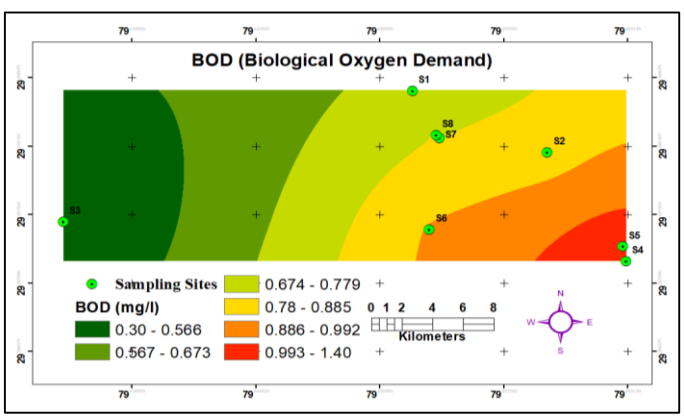


Fig 7. Spatial distribution map of BOD

TDS (Total dissolved solid)

Total dissolved solids, which includes dissolved salts, minerals, and even certain organic substances. The TDS are determined by the residue that is left behind after evaporation of the filtered sample, and the data is reported in mg/l (Mishra et al., 2021). T.D.S. concentrations of the springs vary between 9.41 mg/l to 13.53 mg/l (Fig 8). The minimum TDS observed at Chuna Dhara B (site 8, 9.41 mg/l) and maximum TDS observed at Near Styanarayan Tample (site 3, 13.53 mg/l). If there is a significant concentration of TDS in water, then the pH of the water is probably going to be alkaline.

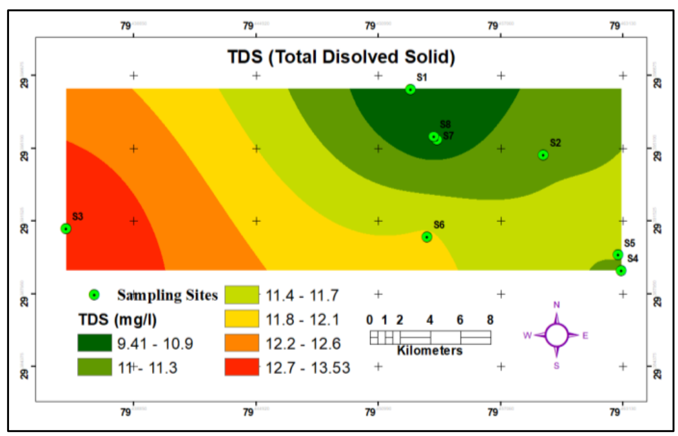
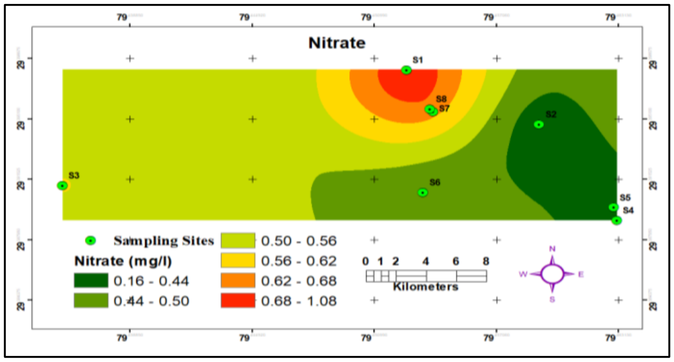


Fig 8. Spatial distribution map of TDS

NO_3 (Nitrate)

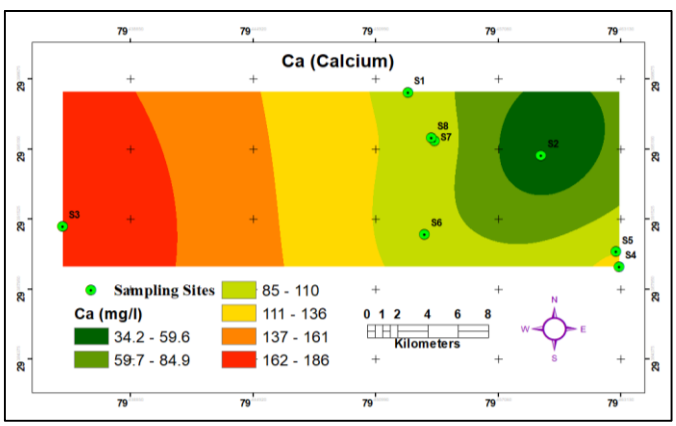
A high quantity of nitrates can lead to algal blooms in the aquatic ecosystem. The values of Nitrate fluctuate between 0.16 mg/l to 1.08 mg/l (Fig 9). The minimum Nitrate concentration was recorded at Near Vimarsh Cottage (site 4, 0.16 mg/l) and maximum was at Near Nishant Hostel (site 1, 1.08 mg/l). The nitrate value that we collected during the study period at different springs revealed that the nitrate level is below the acceptable limit. So, as a result, each spring water is safe for human consumption. Anthropogenic acts have led to a major increase in nitrates in recent years, which is the main concern (Abascal et. al., 2022).



Fihure 9: Spetial distribution map of Nitrate

Ca (Calcium)

The abundance of gypsum rocks in a reaa is responsible for the high percentage of calcium ions (Matrood and Hussein, 2021). Plant tissues contain calcium ions, which play a role in a variety of cellular processes (Pawan and Pradeep, 2015). The value of the calcium very between 34.12 mg/l to 186.24 mg/l (Fig 10). Minimum value of calcium was recorded at Near Ramleela Ground (site 2, 34.12 mg/l) and maximum value of calcium was recored at Near Satyanarayan Tample (site 3, 186.24 mg/l). The calcium ion concentration of all spring water complies with the BIS standard of drinking water for calcium concentration.



Fihure 10: Spetial distribution map of Calcium

Mn (Manganese)

Mn is a transition metal which is found in large amounts in the crust of the earth. It can be found in both surface water and aquifer (Tobiason et al., 2016). Manganese in water can also come from human activities like mining activity, industrial waste, and the percolation process of waste from landfills. In this study, the manganese value deviated between 0.01 mg/l to 0.13 mg/l (Fig 11). The minimum manganese reading recorded at Near Masjid (site 6, 0.01 mg/l) and maximum at Near Ramleela Ground (site 2, 0.13 mg/l). The spring water of all sites are fallowing the BIS standerd of drinking water for manganese concentration.

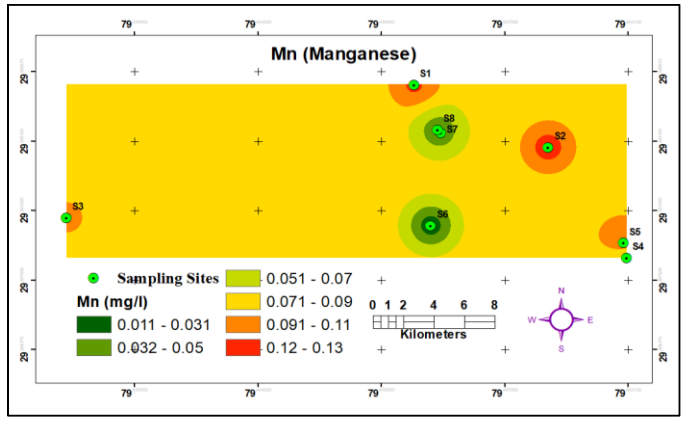


Fig 11. Spatial distribution map of Manganese

Zn (Zinc)

Zinc is commonly found in all water bodies, and its concentration may vary widely in nature (Shikazono et al., 2008). Humans need limited amounts of Zn, and most of it comes from food and drinking water. The zinc concentration varied between 0.01 mg/l to 0.06 mg/l (Fig 12). The lowest value of zinc was recorded at Near Ramleela Ground (site 2, 0.01 mg/l) and highest value was recorded at Near Satyanarayan Tample (site 3, 0.06 mg/l). Most zinc enters water through manmade pathways, but the largest input comes from Zn-containing soil erosion (Noulas et al., 2018).

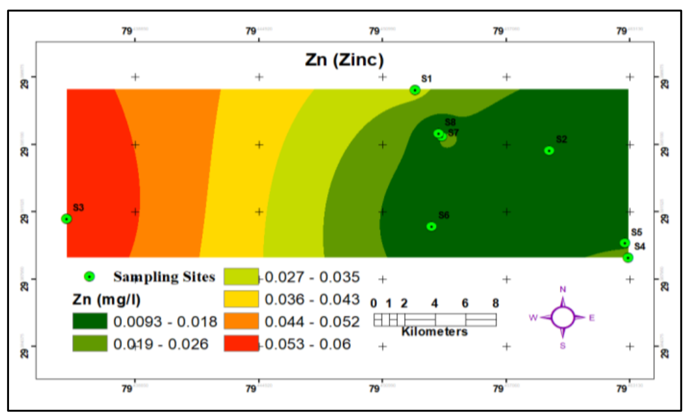


Fig 12. Spatial distribution map of Zinc

TC (Total coliform)

The WHO specification of drinking water for total coliform bacteria is 0/100 ml (Zero coliforms per 100 ml of water), and there is no relaxation in the absence of alternate source of drinking water. The total coliform bacteria in water is not always indicative of water quality problems, but it does raise concerns that the water source could be contaminated with pathogens (Pal, 2014). The total coliform values vary between 0 to 2 (Fig 13). The minimum total coliform concentration was observed at Near Satyanarayan Tample, Near Masjid and Chuna Dhara A (site 3, 6 and 7, 0 in 100 ml of water) and maximum at Near Vimarsh Cottage (site 4, 2 in 100 ml of water). On other springs viz. Near Nishant Hostel, Near Ramleela Ground and Near Bhotiya Band (site 1, 2 and 5) the concentration of total coliform are representing 1 in 100 ml of water. According to the current findings, five sites of the spring sources are indication pollution; it is most likely that it came from the faeces of wild animal and birds etc.

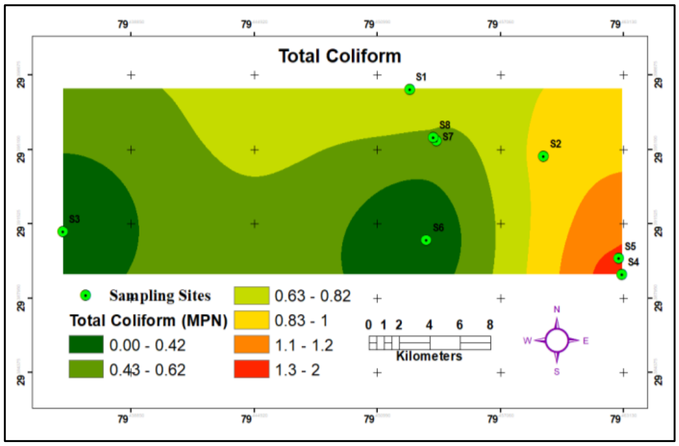


Fig 13. Spatial distribution map of total Coliform

IV. Conclusion

In the Indian Himalayan Mountains, spring water is the primary natural resource for drinking and otherdomestic needs. The springs are thought to be uncontaminated in general; however, contamination by humans and wildlife is always a possibility. According to findings, the spring water quality in Nainital complies with BIS and WHO drinking water requirements. The chemical and physical properties of the water provide the impression that it is fit for human consumption. The geology that lies beneath the water and the chemical make-up of the water have a mutually beneficial interaction. The interpolation, kriging technique of GIS (Geographical Information System) is helping to represent much informative spatial distribution of water quality map in Nainital basin area springs.

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