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Groundwater hydrochemistry of Naulas and Dharas (Springs) of Almora Kumaon Himalayas in Uttrakhand their evaluation using graphical tools

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ABSTRACT

This paper focuses on the water quality status of the springs which are the only source of water of the region. Almora is an important region of Indian Himalayan region (IHR) which is rapidly growing in the population and urbanization that has compromised the ground water quality and even their existence. The onsite disposal of waste and infiltration of contaminants have posed miserable condition of the springs. A total of 21 samples from the springs of the region were collected to study the physicochemical parameters and most of the parameters were seen to be above the guidelines of USEPA and WHO. The quality of water in this paper is evaluated by Durov diagram method and Stiff diagram method. The results of most of the samples revealed that they were not found fit for drinking.

Key words : *Groundwater quality, Springs, Infiltration of the waste, Durov diagram, Stiff diagram.*

Introduction

Springs are underground water sources of the region and these springs are only source of water in the region. The springs in the form of naulas and dharas are the major form of springs in the region. Majority of naulas were thought to be constructed during Katyuri and Chand dynasties between 7th and 8th centuries. The constructions were complicated and involved a number of religious rituals for construction.

Number of steps in naula(conventional pit type springs locally called naulas) is invariably an odd number 5,7,9,11 and so on. The difference between the odd numbers and even numbers is quite intriguing in Uttrakhand. The masons when constructing step ladders anywhere as a general rule, always make odd numbers of steps and would accordingly adjust the height of each step. But perhaps a philosophical explanation account for this is that everything in nature is a flux. While constructing the step ladders of naula opening inlets would be provided at suitable places, usually at top and appropriate cuts were provided at times of need the water source could be cleaned.

The dharas (closed tanks with pipe outlet) are the flowing springs in which the water of the rivers, streams, waterfalls or lakes in mountains cannot be carried over the site of habitation unless it is drawn into some kind of vessel and then carried home. But water flowing in mountains as surface run off or water from springs rundown on the incline of the mountain slope skirting habitations. Such water however cannot be directly used for drinking or

other purposes due to inconvenience involved. So mountain people across the world, since antiquity have deplayed a device that conveys water through it, and clearing the earth, the earth so conveyed is given a clear fall of some height then pours to ground some distance away from its original natural flow. Though the seasons in winter and summer monsoon in uttrakhand, the steep terrain and terrain and the ubiquitous sheet of pine needles accelerates the run off. Despite such adverse conditions the ancient people founds ways to harvest rain water for recharging their aquifers, their naulas. Communities realized that water seeps through pores, fissures and fractures into the underlying aquifers to recharge springs at lower elevations. In between the mountains peaks there are natural formations and depressions of the land. They were used in past for rainwater harvesting. They are known as chalas.

Most of the springs of the town are located along four curved spring lines covering the town with one semicircle each on both the east and west sides of the hill. There is considerable similarity in the locations of the springs on both sides of the hill which indicates possibility of common recharge areas along these drainage lines.

Study Area

The study area is situated in the midst of Himalayas at latitude of 29R 37′3″ and longitude 79R 40′20″ and at 1000 to 2000 meters above the sea level in the Central Himalayan region. This elevation zone is populated and people face the scarcity of water of various magnitudes during summer. The average rainfall recorded varies from 1800-1900 mm of which two thirds is in rainy season (mid June to mid September).winter rains are also common. The average mean temperature varied from 3R Cin winter to 24.9R Cin summers.

Materials and Methods

As per the standard methods all sampling bottles were washed with the filtered sample before filling it and labeled accordingly. The pH and conductivity of the water samples were determined with a digital pH meter and digital conductivity meter respectively. Sodium and potassium were determined using flame photometer. The samples are analyzed to determine the concentration of sodium (Na+), calcium (Ca2+), total dissolved solids (TDS), Alkanility, sulphate (SO42+), Chloride (Cl-), magnesium (Mg2+) and total hardness (Balachandar *et al.,* 2010). The results obtained were compared with the BIS standards (BIS, IS 10500 2009). The concentration of the major cations like Ca, Mg, Na, K and anions like CO_3, SO_4, Cl2 and HCO_3 are determined.

Durov Diagram

Durov diagrams represent the major ion composition, pH and TDS content of any number of samples (Somashekar, 2015). The cations specify the parameters of the left triangle. Default settings are the major cations Na, Ca, and Mg, however any other parameter can be selected (e.g. gas composition, trace elements etc.). The Anions generally specify the parameters for the upper triangle. Default settings are the major anions Cl, SO4, and HCO3, however any other parameters can be selected.

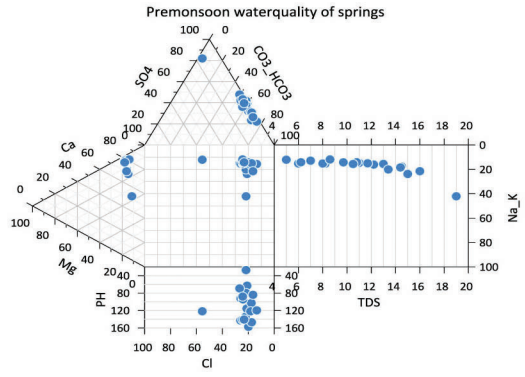
Note that measured Alkalinity is a valid anion parameter, provided the respective parameter is known by the system as being the Alkalinity. This may be done on the File>Database>Alias tab by assigning the respective parameter to the Measured Alkalinity (Manjusree *et al.,* 2009). If using the alkalinity in the anion triangle, change the respective displayed label field to $HCO_3 + CO_3$. In the durov diagram the pH and TDS values are given separate which is easy to identify. Durov diagram is different from piper diagram in the sense that it has additional properties to display as pH and TDS. The visual difference between piper and durov also helps to explain the characteristic of water. The durov diagram indicates that presence of anions are more in post monsoon than in premonsoon water samples. (Shyamala and Jeyanthi, 2016).

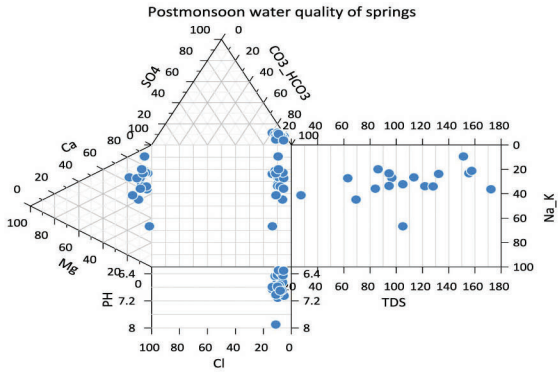
Stiff Diagram

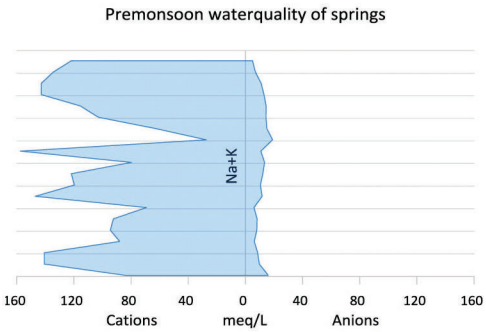
It is used to display the major ion composition of water sample. Stiff patterns are useful in making a rapid visual comparison between water from different sources. The domination of anion is higher in the stiff diagram. Premonsoon water quality shows the dominating characteristics towards Na+ and K+ i.e cations, wheras the postmonsoon waterquality sho slightly more inclination towards cations than ions in the water samples. The anions that are present is more for Cl and HCO_3/CO_3.

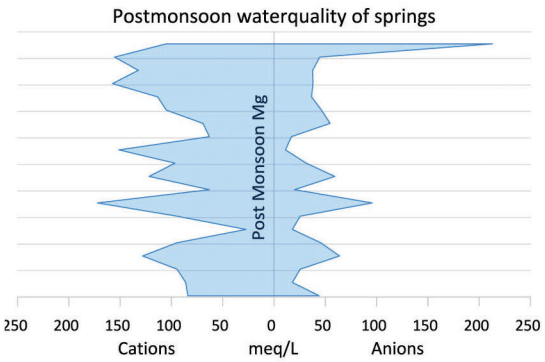
Results and Discussion

The pH, TDS cations, anions have increased in decades. The pH value varied from 6.85 to 7.82 which









is within the permissible limits of WHO. The permissible limit of pH value for drinking water as specified is 6.5 to 8.5 as per IS: 10500 std. The analysis of 21 samples of Almora town specified pH to be over 7.3 in Thapalya dhara. As the case we know that the pure water is not a good conductor of electricity and presence of ions facilitates conductivity. TDS imparts taste to the water and is important parameter to describe the salinity of water.TDS ranged from 587-600 in Thapalya dhara in the present study. The chloride content ranged from 8-10 mg/l which is quite within the permissible limit as the region of fragile mountains is not an industrial belt and also the geological sources of chloride content is rare found in the region. As per IS 10500 standards but in Almora is only over the range of rate value 1103 mg/l. Total hardness of water is characterized by presence of calcium and magnesium salts The presence of Ca ions shows making water hard in both premonsoon and monsoon water. Sulphate ion concenteration is highest in thapalya dhara and Champa naula of about 74 mg/l to 65 mg/l which has increased three times in last few decades (Kumar and Rawat) probably because of infilteration of sulphates as for years this dhara is used for washing clothes and other domestic purposes.

Conclusion

The ground water of the springs of Almora which are the only source of water in the region have deteoriated to this level that most of the sources no more remain fit for drinking. Most of the springs have disclosed themselves from the local sources that people nearby are supposed to boil water before drinking, irrespective to the fact that boiling just is primarily treatment for the water which kills certain microorganisms as well as reduces hardness to some extent. Then water samples of the springs of Almora are continuously deteoriating with the water quality due to unplanned and conventional way of sanitation. The town does not have water carriage system of sanitation and is carrying with conventional way of sanitation. The majority of the buildings still yet under construction are carrying the septic tanks for sanitation. The contamination of springs (naulas and dharas) has increased in the years and most of the springs are not fit for drinking Kumar and Rawat (1996).

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