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Research Article

Geohydrology of Springs in a Mountain Watershed: A Case Study of Takoli Gad Watershed Garhwal Himalaya

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Abstract

Spring discharge is controlled by rainfall, land use, vegetation, grazing incidence and geomorphology of the recharge zone in a mountain watershed in Garhwal Himalaya. In the middle and greater Himalaya, natural springs are the main source of domestic water consumption, but their discharge does not remain constant with time. Erratic rainfall directly affects the recharging of the spring catchment. In this communication, the behavior of a perennial spring with rainfall variation is analyzed from two years data recorded seasonally i.e. winter, rainy, summer. The present work provides spring discharge pattern in a mountain watershed, explores interaction of spring behaviour with rainfall, landuse and other morphological characteristics of the springs, emphasizes water resource management.

Keywords: *Springs, Rain fall.*

Introduction

Water is an integral part of all facets of life, but its uneven distribution both in space and time comes in the way of development needs of the region. Despite the fact that the mountains provide life-giving water to millions of the downstream people through perennial river system. Springs are drying up or becoming seasonal and the difference in the volume of water flowing down the rivers during dry and rainy seasons is commonly more than 1000 times, resulting in too little and too much water syndrome, a common feature of the desert country. Studies indicates that the deforestation, landuse change, intense grazing, reduced water retention capacity of the catchments declining rainfall in some localities, etc. have led to diminishing discharge of the springs (Rawat, J.S. *et al*. 1994).

The recharging depends upon vegetational cover, in addition to the geological and geomorphological controls in the recharge zones. Geohydrological studies suggest that the lineaments produced by joints, fractures and faults play a very significant role on the hydrogeological regime of a catchment (Valdiya, K.S. *et al*. 1989, Valdiya, K.S. *et al*. 1991). Hydrological parameters, such as steam flow, runoff and interception loss, depend upon the amount and intensity of the rainfall, the density of tree crown and the branching pattern of tree (Ovington 1954, Rutter 1963, Raynolds and Henderson 1967, Dunne *et al*. 1991).

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Location of the area

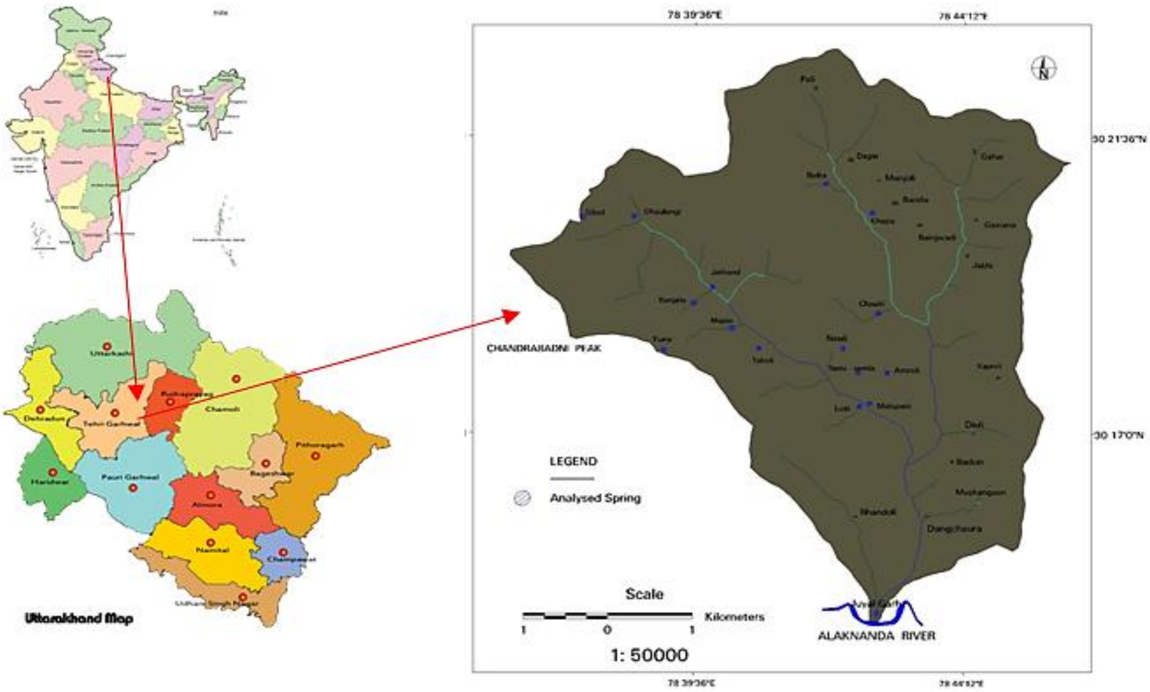
Geographically the catchment (Takoli Gad) is lying between the 30^0 14′ to 30^0 23′ N latitude and 78^0 37′ to 78^0 46′ E longitudes in the Survey of India toposheet No. 53 J/11, 53 J/12 and 53 J/15 with an area of about 131.43 Km^2. It comes under jurisdiction of district Tehri Garhwal, Uttarakhand. The area is approached by Kirtinagar-Tehri and Kirtinagar- Chauki all weather roads. The area falls in inner Garhwal lesser Himalaya and is characterized by gentle and mature topography. The Takoli Gad originates from the Eastern slope of the Chandrabadni Peak (2278 meter) and join the Alaknanda at Juyal Garh (605 meter). Jakhand and Dagar Gad are the two main sub streams / tributaries of the Takoli Gad watershed.

Methodology

The monitoring of water discharge was conducted in three main seasons i.e. winter, summer and monsoon of 2007-2008. 12 springs in phyllite terrain and 3 springs in quartzite terrain of Takoli Gad watershed were selected for this study.

Location and Characteristics of Springs

Where the surface of the slope meets or intersect the water table, ground water moves out in the form of springs and seepage. Extensive field study in the area, was carried out to identify significant features of the spring zones.



Map 1: Location of springs

Table 1: Springs of the catchment

Spring No.	Name	Altitude (a.m.s.l) (Mt.)	Rock Type
S_1	Dhaulangi	1234	Phyllite
S_2	Jakhand	1077	Phyllite
S_3	Banjela	1201	Phyllite
S_4	Majdai	920	Slate
S_5	Raj Gad	919	Slate
S_6	Malupani	914	Phyllite
S_7	Lusi	818	Phyllite
S_8	Amroli	1088	Phyllite
S_9	Semisemla	1180	Phyllite
S_{10}	Neuli	1239	Phyllite
S_{11}	Tiuna	1613	Phyllite
S_{12}	Silod	1710	Phyllite
S_{13}	Chauki	1050	Quartzite
S_{14}	Khajra	1165	Quartzite
S_{15}	Belta	1240	Quartzite

Very gentle slope or almost up slope areas are conducive to development of a good hydraulic gradient, adequate recharge and quicker movement of ground water viz Malupani, Amroli, Semi semla and elsewhere. Beneath the valley floors the ground water occur largely as disconnected local bodies in favorable perched aquifers in both semi confined and unconfined conditions and also in zones of jointing, fracturing and faulting. The colluvial deposits are highly porous and permeable and therefore hold good quantity of waters. Following table 1 depicts location and other characteristics of various springs indentified in this catchment.

Spring in Phyllitic Terrain

Dhaulangi (s_1)

Thinly folded and steeply dipping, khaki color phyllites are exposed around the spring. The spring occurring at an altitude of 3702 feet msl, scattered trees with cultivated land constitute the main landuse pattern of the area. The average discharge during (2007-2008) the summer season 680.5 l/s, monsoon season 2668 l/s and winter season 987.5 l/s respectively (Table 2).

Table 2: Total Water Discharge of Springs of the Catchment (2007-2008)

S.No.	Spring Name	Discharge (l/h)					
		Summer		Monsoon		Winter	
		2007	2008	2007	2008	2007	2008
S_1	Dhaulangi	857	504	836	4500	947	1028
S_2	Jakhand	2732	2152	2915	5690	1992	1872
S_3	Banjela	2048	1456	2278	5010	1288	1166
S_4	Majdai	1548	936	1800	4500	792	666
S_5	Raj Gad	1188	576	2124	2250	782	1000
S_6	Malupani	280	490	764	2769	1383	1200
S_7	Lusi	1286	1026	2999	3000	2769	800
S_8	Amroli	764	587	947	1636	826	782
S_9	Semisemla	353	179	278	734	339	232
S_{10}	Neuli	101	30	108	226	104	79
S_{11}	Tiuna	209	209	1635	3600	857	780
S_{12}	Silod	3042	2450	3418	6172	2284	2160
S_{13}	Chauki	956	678	1256	1985	940	1028
S_{14}	Khajra	1648	1555	3570	5710	2688	2824
S_{15}	Belta	1372	1040	1840	2755	1265	1440

Jakhand (s_2)

Pauri phyllite with thick pile of scree deposits is exposed around this spring. Situated 1077 mt amsl. The spring is surrounded by few cultivated fields. The average discharge during (2007-2008) the summer season 2442 l/s, monsoon season 4302.5 l/s and winter season 1932 l/s respectively (Table 2).

Banjela (s_3)

The spring is located at 1201 mt amsl. Scattered trees with cultivated land constitute the main landuse pattern of the area. The spring occurs fractured Khaki colored phyllite is exposed near the spring. The average discharge during (2007-2008) the summer season 1752 l/s, monsoon season 3644 l/s and winter season 1227 l/s respectively (Table 2).

Majdai (s_4)

Green with khaki color slates are exposed near the spring which lies at an altitude of 2762 feet amsl. The spring is surrounded by cultivated fields. The average discharge during (2007-2008) the summer season 1242 l/s, monsoon season 3150 l/s and winter season 729 l/s respectively (Table 2).

Raj Gad (s_5)

Green with khaki color slates are exposed near the spring which lies at an altitude of 2760 feet amsl. The spring is surrounded by cultivated field. Construction of foot path near spring considerably reduced the discharge as reported by villagers. The average discharge during (2007-2008) the summer season 867 l/s, monsoon season 2187 l/s and winter season 891 l/s respectively (Table 2).

Malupani (s_6)

Green colored fractured phyllites are exposed near the spring which lies at an altitude of 2744 feet amsl. Construction of paindula – Maikhandi road considerably reduced the discharge as reported by the villagers. The average discharge during (2007-2008) the summer season 385 l/s, monsoon season 1766.5 l/s and winter season 1291.5 l/s respectively (Table 2).

Lusi (s_7)

Green colored, folded phyllites are exposed near the spring which lies at an altitude of 2454 feet a.m.s.l. The spring is surrounded by few cultivated fields, up slope is steep and sparsely vegetated with pine. The average discharge during (2007-2008) the summer season 1156 l/s, monsoon season 2999.5 l/s and winter season 1784.5 l/s respectively (Table 2).

Amroli (s_8)

Green colored phyllites are exposed near the springs which lies at an altitude of 3264 feet a.m.s.l. The construction of road along recharge are has decreased the discharge of this perennial spring. The average discharge during (2007-2008) the summer season 675.5 l/s, monsoon season 1291.5 l/s and winter season 804 l/s respectively (Table 2).

Semi-Semla (s_9)

Fractured green colored phyllites are exposed around the spring, located at 3541 feet a.m.s.l. The spring is surrounded by cultivated fields. Steep slope with scattered vegetation form the recharge area of the spring. Effect of rainfall on discharge of this spring is very significant. Discharge of spring increases during rainy season whereas it constantly diminishes during summer. The average discharge during (2007-2008) the summer season 266 l/s, monsoon season 506 l/s and winter season 285.5 l/s respectively (Table 2).

Neuli (s_{10})

The spring located at 3718 feet a.m.s.l. The spring occurs fractured khaki colored phyllite is exposed near the spring. The average discharge during (2007-2008) the summer season 65.5 l/s, monsoon season 167 l/s and winter season 91.5 l/s respectively (Table 2).

Tiuna (s_{11})

Greenish color folded phyllites are exposed near the spring which lies at an altitude of 4841 feet amsl. The spring is surrounded by cultivated fields. The average discharge during (2007-2008) the summer season 209 l/s, monsoon season 2617.5 l/s and winter season 818.5 l/s respectively (Table 2).

Spring in Quartzitic Terrain

Chauki (s_{13})

Purple, brown, coarse grained quartzite is exposed near the spring, located at 1050 mt amsl and is surrounded by lantana shrub and no significant vegetation is reported in the recharge area. The average discharge during (2007-2008) the summer season 817 l/s, monsoon season 1620.5 l/s and winter season 984 l/s respectively (Table 2).

Khajra (s_{14})

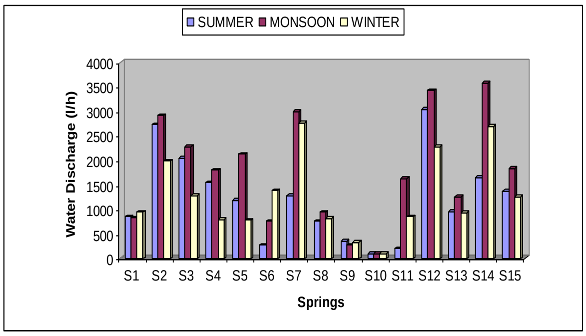
Brown coarse grained quartzite is exposed near the spring, located at 1165 mt amsl. The spring is surrounded by pine forest. This spring just below the Dugadda- Belta road. The average discharge during (2007-2008) the summer season 1601.5 l/s, monsoon season 4640 l/s and winter season 2756 l/s respectively (Table 2).

Belta (s_{15})

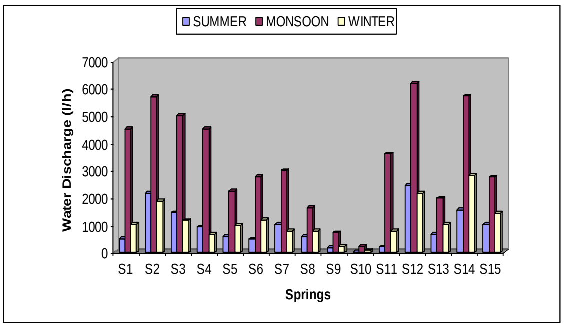
Highly jointed quartzites of pink colour are exposed near the spring which occur at 1240 mt amsl and . The spring is just above the Dugadda- Belta road. Abnormal geomorphic features viz deep gorge of dried stream show some neotectonic disturbance and fractures in the quartzite which seems to be responsible for the location of this spring. The average discharge during (2007-2008) the summer season 1206 l/s, monsoon season 2297.5 l/s and winter season 1352.5 l/s respectively (Table 2).

Water Discharge

Seasonal discharge of spring and stream was measured during the course of study. Discharge values of representative springs of this catchment is depicted in the table 2.



Year 2007

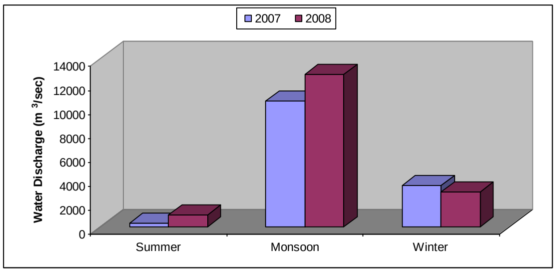


Year 2008

Fig.1: Total water discharge (l/h) in Springs and Stream Water of the Catchment (2007 & 2008)

Table 3: Total Seasonal Water Discharge of Takoli Gad Watershed

Season	Discharge (m^3/sec)	
	2007	2008
Summer	290.84	958.74
Monsoon	10475.00	12727.44
Winter	3439.72	2874.70



Rainfall

The area receives maximum precipitation in the months of July, August, September (2007) and June, July and August in 2008. In both the Years January was a dry month. Total annual rainfall in the study area was recorded 2029 mm (at Paindula) and 2055 mm (at Tiuna) in 2007 and 2662 mm (at Paindula) and 2684 mm (at Tiuna) in 2008. (fig 1). There is no significant difference in the extent of rainfall between the places at same altitudes. However, the south-east slopes receive less precipitation than the north-western facing slopes, also sites at lower elevation receive lower rains than those at higher altitudes, owing to altitudinal variation and the orientation of the monsoon winds.

Table: 4 Total rainfall of the area

Year	Station & Height	Jan. (mm)	Feb. (mm)	Mar. (mm)	Apr. (mm)	May (mm)	June (mm)	July (mm)	Aug. (mm)	Sep. (mm)	Oct. (mm)	Nov. (mm)	Dec. (mm)
2007	Paindula 740 mt	-	-	94	-	185	202	497	497	513	41	-	-
	Tiyuna 1614 mt	-	-	98	-	184	207	508	502	517	35	4	-
2008	Paindula 740 mt	-	103	-	141	244	604	722	547	220	5	70	6
	Tiyuna 1614 mt	-	114	-	155	248	592	718	565	213	6	66	7

Conclusion

It is clear from table 2 that summer witnessed least discharge and monsoon had maximum. As usual the river remains in spate during monsoon when over bank flow inundates low lying areas causing heavy down pour of sediment loads. Total discharge of monsoon season during 2007 is 10475.00 m^3/sec and during 2008 is 12727.44 m^3/sec. It can be visualized that how worst is the fate of populace. Virtually, the flow of water remains very little or negligible in the stream during summer i.e April-may, at one or the other place, but during rains, the vigorous over bank flow causes havoc and washes everything that comes in the way of fiery stream. Therefore rain water harvesting seems only means to minimize the loss by this event. Looking at the hydrological behavior of these springs, it can be emphasized that each spring has its own character which is influenced by a combination of factors operated in the recharge zone. Understanding the site specific nature of the springs, their response to rainfall, landuse, biotic pressure and sociological constraints and limitations of our knowledge with regard to revival of springs, the following areas of problem solving research in this region may be suggested- (i) Water harvesting, conservation of spring sanctuaries, studying recharge and discharge pattern of springs, collection and analysis hydrometrological data (e.g. rainfall, runoff, evapo-transpiration etc.); (ii) traditional water conservation/management system; (iii) identification of plants which can help in augmenting ground water recharge; and (iv) strengthening water management system and role of technological inputs to check water misuse and losses. (Negi G.C.S *et al*. 1996)

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