Development of seepage spring for rural water security

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Abstract. Springs are the lifeline of the Himalayan region. Local Communities are fully depended on spring water for drinking and household use. At present climate change scenario, majority of springs are either dried or have become seasonal. Water demand is also increasing day by day in this region with an increasing population. To sustain in this changing scenario, communities are fulfilling their water needs by developing seepage spring using traditional knowledge. Seepage springs are normally not of sufficient volume of water to be flowing beyond their above-ground location due to very low permeability which may or may not have high porosity. The seepage discharge can be enhancing by increasing the seepage surface by excavating caves of suitable dimensions. Developed seepage spring discharge rate is less but an optimum designed harvesting spring water collection box will be providing the assured water supply to local communities. It may full fill the 30-40 villager’s daily requirement of water in the dry period (i.e., December to April). In the present paper, steps of spring development including the design of the spring box are described. The development cost of spring is cheap if locally available material is used and tapping the water for distribution is also cheap due to gravity flow water supply system. The developed spring provide assured supply of clean drinking water to residents, livestock and wildlife throughout the year. The development technique of spring can be valuable for survival purpose human and helps the local wildlife by adding another source to the region.

Keywords: Development, Water demand, Tapping, Seepage, Spring box.

1. Introduction

Springs are the lifeline of the Himalayan region. It exists almost everywhere and plays an important role in the Himalayan ecosystem. Most of the community’s lived in the top of the ridge and low altitudes, springs play an important role in their survival [1,2]. So, rivers that flow in valleys limit its utilization for water supplies, and also utilizing groundwater aquifers in the hilly landscape is most difficult and costly [3]. Many studies revealed that about 80 – 90 per cent of the population of the Indian Himalayan region mostly depends on springs [4].

So, mostly springs water has been used as domestic purpose (such as drinking, washing), for cattle care, agricultural use [5] and ponding of water for fish farming. So, it is a proven fact that local communities are fully dependent on spring water for domestic uses [6,7]. Apart from humans use springs helps to maintaining baseflow of perennial rivers [8], maintaining the Himalayan ecosystem and providing drinking water for the wild animals. At present climate change scenario, this important resource is also greatly affected, the majority of springs are either dried or have become seasonal. The
changed precipitation pattern reduced the recharging time of spring catchments. The geological formations are responsible for recharging the spring’s catchment, in this changing scenario surface are not getting ample time to saturate fully. A spring catchment may consist of more than one formation with different geohydrological properties [9]. The time required to recharge and discharge the highly permeable formations is comparatively less than the formations having lower permeability. Concerning these, the formations with lower permeability get lesser opportunity time to recharge from a smaller-duration intense-rainfall event and vice versa. Therefore, the amount of precipitation received by highly permeable formation mostly drained out due to intense rainfall in the monsoon season. So, the aquifer is not recharged well and now, the average flow rate of perennial springs is diminishing year by year [10].

Apart from the climatic change anthropogenic activities are also responsible for the diminishing of spring discharge such as deforestation, cutting of hills for new construction, rapid and undesirable population expansion and the mishandling of available key natural resources [11,12]. For the sake of tourism business, expansion of hotels and retreats in spring catchments further worsen the situation for the local communities [9]. Now, these regions experience an acute shortage of water in lean period. Shortage of water greatly affects the women and children. They play a key part in domestic water management such as collecting, storing, and utilizing water and for disposing of wastewater. In rural areas, if nearest springs are dried up due to above-enlisted reason, children and women get up early morning and have to cover very exhausting distances to collect water for fulfilling the daily water requirement of the family. Studies have shown that the drying trend of perennial springs in the lean period greatly affect the women and children [13]. According to a report, the responsibility of collecting potable water is bear by women (72 per cent) and children (14 per cent). For daily water collection, about 60 per cent of the women have to walk half a kilometre, whereas 10 per cent of women walk 4 km [6]. So, the significance of springs cannot be ignored. To deal with this water-scarce scenario, it is necessary to harvest potable water when it is an excess, rejuvenation of springs, protection of springshed and development of seeps/spring [14]. This paper highlights some of the development techniques of seepage spring. The development technique of spring can be valuable for the survival of human and wildlife by adding another water source to the region. The development procedure of seepage springs is the most difficult. They are easily contaminated because of groundwater over a wide area from sources that may be very close to the surface.

In some of the region, local communities are developing seepage spring using traditional knowledge to fulfil their water requirements. Seepage springs are normally not of sufficient volume of water to be flowing beyond their above-ground location due to insufficient permeability that may or may not release water due to poor porosity. The discharge of seepage spring can be enhancing by increasing the seepage surface by excavating caves of suitable dimension. The average flow rate of these developed seepage springs is very low but it provides assured water supply by constructing of spring water collection box. The development cost of spring is cheap if a locally available material is used and tapping the water for distribution is also cheap due to gravity flow water supply system. The developed spring provide assured supply of clean drinking water to local communities, livestock and wildlife throughout the year [14].

1.1 Community participation
It is a very important component of all water supply projects that requires timely maintenance and long-term sustainability as its objective. So, local communities are a part of each step of any project. Community members help to locate springs site that was traditionally used by their villages. They know the spring discharge variation and other site conditions.

1.2 Advantages of seepage spring development
- A clean and free source of water,
- Electricity for pumping is usually not needed,
- Water availability in dry months (i.e., December to April) or throughout the year,
- Water availability reduces the hectic task of women and children,
• Spring development cost is also inexpensive compared to wells and ponds, due to gravity flow.
• Proper spring development also helps to protect the water from contamination.

1.3 A properly developed spring should have the following characteristics:
• No contamination sources.
• The watertight covered structure prevents the entry of any insects, dead animals, leaves and also contaminated surface water.
• If necessary, then, also install disinfection equipment, gravel or sand filters.
• Silt, dead animals and other organic and inorganic materials will avoid.
• Spring box should be sealed to avoid any contamination

2. Seepage spring development
Seepage spring and seeps will develop as per the site conditions such as the area of seepage face and its height from the surrounding area. Spring can be developed in several different ways, as shown below. There is no hard and fast rule for developing of seepage spring or seeps; it can be developed as per site conditions.

2.1. Cave excavation:
The finding of seepage profile is prerequisite in the initial buildout phase of seepage spring which is mostly based on its characteristics during the historical offseason. Subsequently, identification of appropriate whereabouts, excavating the seepage face horizontally to form a cave-like structure in the profile of the arch. The main concept of cave development is to allow water to drain out from within the excavated face. The complete technical knowhow of cave development [14] is explained in figure 1.

Figure 1. Seepage spring, (a) shows the seepage face and seepage line, (b) inside view of the cave [14]
The top-most portion of seepage face below which seepage takes place or horizontal or slant interface among dry and wet segments of the saturated soil mass is termed as seepage line (figure 1a). It separates the saturated soil mass to above saturate soil mass. It also indicates the water table in the geological formation (figure 1a). Excavate cave at a lowermost possible portion from the seepage line in the seepage face. Pressure head enhanced seepage discharge after the excavation of cave at the lowermost possible position of seepage line, it provides water supply for a longer duration. Discharge rate and capacity of spring are dependable of aquifer permeability. The exposed surface of the excavated cave contributes discharge until the water level in the formation is above the top portion of the excavated cave face. The seepage face contributing discharge may decrease regarding the diminishing water table, saturated zone near the seepage area within the catchment and the site of the cave. Additionally, the length and circumferences of excavation cave depend on the desired discharge rate, strength of formations materials to resist cave-in and mostly depends on the excavator experience. Do not use any kind of support such as walls and roofs, during and after completion of the excavation of cave. According to the user’s experience, the diameter and length of the cave should not exceed more than 1m to prevent possible collapsing either due to its weight or roaming of animals. Besides, excavation of more than one seepage site is advisable and ideal on the place of larger dimensions single site to avoid any type of collapsing of formation and many other possible problems [14].

**Advantages of Cave Development:** After excavation of cave more seepage discharge is available due to more pressure head and this tiny water source provide assured water supply during dry periods (i.e., from December to April) and also throughout the year. It is reported that, during the peak of the dry season, seepage springs (diameter and length equal to ~ 0.5 m each) discharge between 1-2 litre minute$^{-1}$ [14]. If this water is harvested in an optimum designed harvesting structure the total water daily average water stored is about 1440-2880 l/day, which is enough for 20 to 40 persons in a village (standard daily average water requirement is 135 litre per day, as per the Central Public Health and Environmental Engineering Organization).

### 2.2. Development of harvesting structure

Seepage spring development involves a series of steps and stages such as

- **Survey of catchment area:** To identify the potential location of seepage faces, types of land use in the catchment, geological formation, sources of contamination, accessibility and other potential problems. Is there any construction is possible? If yes then, what type of construction will be needed?

- **Initial Investigation:** Conduct a questionnaire survey to collect the historical information of seepage face or spring. Such as flow rate of seepage face/spring, Is it available in dry period? Also, conduct some experimental task to know about the geological formation. Measure the flow rate of seepage face by inserting pipe and temporary dike and record the time needed to fill a known volume of the container. To find the average flow measure it several times and dry period is the best time to check the flow rate. Also, check the water quality of the water source. If there is a need for disinfection or need of settlement of suspended particles provide the necessary provisions in the final design.

#### 2.2.1 Construction of spring box (shown in figure 2)

Firstly, clean that area and dig out around the seepage face up to 3 m or where you hit the rock underneath the soil. Make a reservoir with help of gravel bed to intercept the flow of water. Make a gravel bed to form a reservoir to intercept the flow of water. Install a cut-off wall on the downward side of the slope made from concrete or plastic. Attach a perforated pipe at a lower point in the cut-off wall to collect channel water in the spring box. Make sure that the water will not back up behind the cut-off wall. The main tank is connected with pipe to transfer water at the community level or storage tank [15]. Install a gravel filter or sand filter or both sand and gravel filter as per requirement. Gravel filter helps to remove the larger size particles such as dead animals and decay leaves or roots. However, sand filter or sand bed retain the suspended particles and
supply the turbid free water or in the permissible limit as per WHO and BIS. Sandbeds also removes the harmful bacteria from potable water and supply safe water to the community [16].

**Figure 2.** Water collection from the seepage area (Source: USAID)

2.2.2 *Construction of series of spring boxes/structure.* Harvesting structure can be developed at the site where water discharge is available in some quantity from seepage face and cave excavation technique is not suitable due to height of seepage face from the surrounding area (figure 2).

**Figure 3.** Photograph represents the water collection from two seepage face of Lower RGU spring.
At this situation, water collection structure series will be developed as per site condition such as a single structure or series of structure. Spring located near Rajiv Gandhi University, Arunachal Pradesh (lat/long: 27.14/93.76) shown in figure 3. This seepage spring is perennial and recharge area is dominated by forest. There are two major seepage faces are available at this site. So, a series of a spring box and water collection structure is constructed. Seepage water is collected in the main tank (3) from both seepage face 1 and 2. Seepage water is first collected at the tank (11) and tank (21). Collected water transported through the pipe by gravity flow at the storage tank at the house.

3. Conclusion
Springwater has been harnessing as the main sources of water for domestic uses by the inhabitants residing in mountainous regions from centuries, but in recent years, its discharge has been diminishing slowly and most of it has dried up. This situation has led local communities facing a drastic domestic water crisis, which forced them to travel a long distance to collect fresh water from other sources downstream. In contrast to these inconveniences caused to them, seepage spring/seeps development and management is one of the keys/ alternate way out to avail fresh water to the local communities. The discharge rate of the seepage spring is very low but proper management of these small water sources will provide assured water supply during the dry periods of the year. By adopting the different seepage spring development techniques such as cave excavation, spring box construction at seepage area, water collection structure at different seepage faces, will fulfil the water needs of local communities/stakeholders throughout the year. Proper spring development also helps to protect the water from contamination.

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