Water in Soil Profile and Sub-Strata and Watershed Development in Central Himalayas for Perennial Community Water Supply

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Communities living in the Central Himalayas of India have been meeting their requirement of water from sources such as traditional *naula* – a small seepage collection tank on hill slope, and its improved version – the Infiltration Well, Springs and small order streams (Das, 2000).

Hydrologic studies carried out in the region detected a steady decline in spring as well as channel discharges and collection into *naulas*. Some of these have become seasonal and quite a few have even dried up. This has been concurrent to widespread denudation of natural forest cover and unabated erosion.

These studies have concentrated on surface and spring hydrology while treated springs as part of ground water or manifestation of ground water. While the relevance of seepage as a process and water in soil profile and sub strata as an immediate source, have not been dealt with (Valdiya *et al*, 1993; Kadekodi *et al.*, 1997).

An UNDP sponsored feasibility study of the infiltration wells – an improved version of *naula* revealed the centrality of these two in the context of hydrologic continuum or whole as well as of sustainable water supply to the communities (Fig.1) (Rees, 1996).

Examination of research results, field experiences and actual occurrence of springs vs first and second order streams and traditional *naulas* on the hill slopes established that seepage flows are the ultimate source for all these three and determines the extents of incident rainfall that could be disposed of as surface or immediate runoff and sub surface runoff.

An examination of actual occurrence of the springs in Khulgad watershed in Gaula river catchment reveals following interesting features :

- Springs are more found on upper reaches of the watershed and concentrated on saddles or intersections of the slopes,
- These are clustered close to the heads of first or second order streams,
- Initiation of channel flow often and its perenniality seem to start with contributions from one or more number of springs,
- Springs are found in areas with some specific geologic features (Table 1),
- Discharge and perenniality is substantially regulated by type, extent and quality of vegetation besides slope length above and elevation difference from the ridge line.

This last feature is a very distinct one than those which involve in a typical analysis of ground water hydrology. This reveals a distinct perception and thus a separate identity for this volume of water.

The process analysis revealed a different perception of this water volume which is absorbed, stored and transhifted variously within soil profile and sub-strata. This volume of water has a distinct identity in the hydrologic continuum or whole and for making watershed project sustainable (Fig.2) (Das, 2000; Hufschmidt and Tejwani, 1993; Bruizneel and Bremmer, 1989; Chyurila, 1984; Hewlett and Hibbert, 1967).

It was thus necessary to determine relevant principles and document the processes involved so that future ameliorative programmes could be based on better rationale. The hydrologic process of formation of a spring is shown in Fig.3 specially depicting the push through mechanism described by Hewlett and Hibbert (1967). While pereninality of small to higher order streams due to seepage is shown in Fig.4.

Seepage volume and rate however, depend upon infiltration and penetration of rainwater, various storages in soil profile and sub-strata. Type, extent and quality of vegetation regulate this. Its final exit from hill slopes however, depends upon geology that provides a gradient, spaces for transitory accumulation and facilities to move out as free interflow or as a push through outflow. This is distinct from aquifer based ground water or well hydrology and is combined from the results of resistivity survey that could not identify site for bore well but indicated patches of moist and parched slopes (UOR, 1996).

Table 1 Distribution of Natural Springs in four distinct Geological settings in Khulgad Watershed

Sl. No.	Geological situations	Total No. of springs	Percent of total	Villages near around	Attitude (m)
1	Thrust and Fault related with extensive and massive crushed layer of quartzite and schist	69	42	Salla-Rautela - Sitalakhet -Syahidevi - Bhakar etc	1600 to 2000 plus
2	Joints (vertical or inclined) related crushed rocks of quartzite	33	20	Deolikhan	1600 m around
3	Sheared & Shattered Zone with Dip related characterised with fractured	41	25	Khunt to Dhams Dhali to Matela	1400 to 1500
4	Sheared and joints related marked with anti dips and fractured quartzite layer	22	13	Around Jyoli, Kharkund etc.	1300 to 1400
	Total	165	100		

The process analysis revealed the distinction of soil profile (Biomass Production Zone) and sub strata (Non Biomass Production Zone) within the total hydrologically operative depth (HOD) in influencing hydrologic status and responses of a watershed (Fig.2). The pattern, volume and rate vary with soil cover complex that also determine the HOD (Fig.5) (Das *et al.*, 1970; Das, 2000).

Results also show that for larger and perennial supply 80 percent of rainfall should be absorbed on site and overland flow as well as surface runoff should be less than 20 percent of rainfall (Alford D quoted from Joshi *et al.*, 1996).

Table 2 Comparative hydrologic responses of Forests with three dominant species

Parameters	Low altitude – 1,000m to 2,000 m			High Altitude 2,000m to 2,600 m			Desired value
	Sal	Oak	Pine	Horse chest nut	Oak	Silver fir	
Canopy through fall (%)	80.2	79.2	66.5	87.0	79.8	72.5	Normal
Canopy Interception (%)	17.7	20.1	32.4	12.8	20.1	27.5	Normal
Stem flow (%)	2.16	0.44	0.31	0.18	0.09	0.01	1 to 2
Over land flow (%)	0.78	0.39	0.94	0.25	0.31	0.01	20.00 & less
Infiltration + Forest floor storage (%)	81.6	79.3	65.9	86.9	79.8	72.5	Between 80 & 90
Sediment Production (Kg/(ha • Year))	57.2	19.2	33.5	45.7	16.3	9.2	30

Sal = Shorea robusta : Evergreen clear bole, leaf life span <1 year
Oak = Quercus spp : Evergreen rough bark, leaf life span > 1 year
Pine = Pinus roxburghii : Evergreen rough bark, leaf life span ⩽ 1year
Horse Chest nut = Asculus India, deciduous, leaf life span < 1 year
Oak = Quercus semicarpifolia, Evergreen, leaf life span ⩾ 1 year
Silver fir = Abis pindrow, Evergreen, leaf life pan ⩾ 3 year

The water balances for 12 months and the year (Kadekodi *et al.*, 1997) for the East Ramganga catchment provide the break-up of the constituents of total runoff (TRO) into surface runoff (SRO), sub surface runoff (SSRO) and snow melt runoff (SMRO). The interesting features are :

- Immediate or surface runoff constituted only 10.7 percent of the total runoff or river flow,
- Whereas sub surface runoff accounted for 41.4 percent of the total runoff,
- Snow melt runoff represented 48 percent of total runoff,
- Surface runoff was generated only in 10 months when rainfall alone or with snow melt too occurred. While snow melt runoff was there for eight months,
- Whereas sub surface runoff was in all months even in those when there was no rainfall and those saw no snow melt inflows,
- Further the SRO ranged from low of 2.35 mm to a high of 439.04 mm and SMRO varied from 10.15 mm to 1777.22 mm. But SSRO maintained a more equitable flow distribution ranging from 313.31 mm to 465.32 mm.

This is achievable under good, broad leaf species like Oak and then well managed pine forest or mixed ones. The effort on degraded areas could be more rewarding if soil and water conservation measures are also included.

It was also revealed that the support areas of the village, if managed under such vegetation, which are hydrologically beneficial, could also help the village meet most of their requirement of fuelwood, fodder etc.

It has, therefore, become necessary to rejuvenate community driven activities like regeneration of right type of vegetation, undertake soil and water conservation measures on slopes, and manage these on seepage sheds for preserving perenniality and for augmenting availability of water through out the year.

It is concluded that seepage as a hydrologic process while soil profile and sub-strata as the real and immediate source for dependable and equitable sub-surface flow through out the year should receive greater attention in research as well watershed development planning, particularly in hilly and mountainous areas.

References

Bruizneel, A. and Bremmer, C.N. (1989) : High lands-Low lands interactions in Ganges – Brahmaputra river basin. A review of published literature, Occasional Paper No. 11 ICIMOD, Kathmandu.

Chyurila, C.P. (1984) : Water Resource Report. Land Resource Mapping Project. Kenting Earth Sciences Ltd. Ottawa pp.273.

Das, D.C.; Raghunath, B. and Thomas, P.K. (1970) : Rainfall disposition studies on small plots at Ottacamund (India). International Symposium on the results of research on representative and experimental basins. Wellington, New Zealand IASH-UNESCO Publn No.96:297-308.

Das, D.C. (2000) : Report on Techno-Economic Appraisal of Deep Infiltration Wells / Hand Pumps in the Kumaon Himalayas. UNDP sponsored Pan Himalayan Grassroots Development Foundation (Grassroots), Ranikhet, Kumaon, pp.92.

Hewlett, J.D. and Hibbert, A.R. (1967) : Factors affecting the response of small watershed to precipitation in humid areas. Forest Hydrology Ed. W E Sopper and H W Lull. Pergamen Oxford : 275-290.

Hufschmidt, M.M. and Tejwani, K.G. (1993) : Integrated Water Resource Management : Meeting the Sustainability Challenge. UNESCO, IHP Tropic Prog. Series No.6.

Joshi, Varun and Negi, G C S (1996) : Hydrometeriological studies in two land use practices in Garhwal, Studied in Indian Agro-system, Ed Pathak, P S and Gopal, B. Nat Instt of Ecology, pp. 15-21.

Kadekodi, G.K.; Murthy, K.S.; Kumar, Kreet; Adhikari, S.K.; Satyal, G.S. and Subba Rao, D.V. (1997) : Valuation of Water. The case of Kumaon region. Institute of Economic Growth, Delhi. pp-180.

Negi, G.C.S.; Rikhari, H.C. and Garkoti, S.C. (1998) : The hydrology of three high altitude forests in Central Himalayas, India : A reconnaissance study. Hydrological Process. vol.12 : 343-350.

Rees, D.G.T. (1996) : Infiltration Well Technology for Hand Pumps in the Himalayas. Rajiv Gandhi National Drinking Water Mission. Min. of Rural Area and Employment, GOI, New Delhi. pp.12.

UOR (1996) : Electrical Resistivity Survey for locating bore well sites around Sitala & Mukteshwar. Kumaon Region, Department of Earth Science, University of Roorkee, Roorkee, pp.17.

Valdiya, K.S.; Rawat, J.S. and Rai, S.R. (1993) : Responses of Hydrologic Cycle of Khulgad Watershed, Kumaon Himalayas. Central Himalayan Environmental Association. Nainital. pp.78.

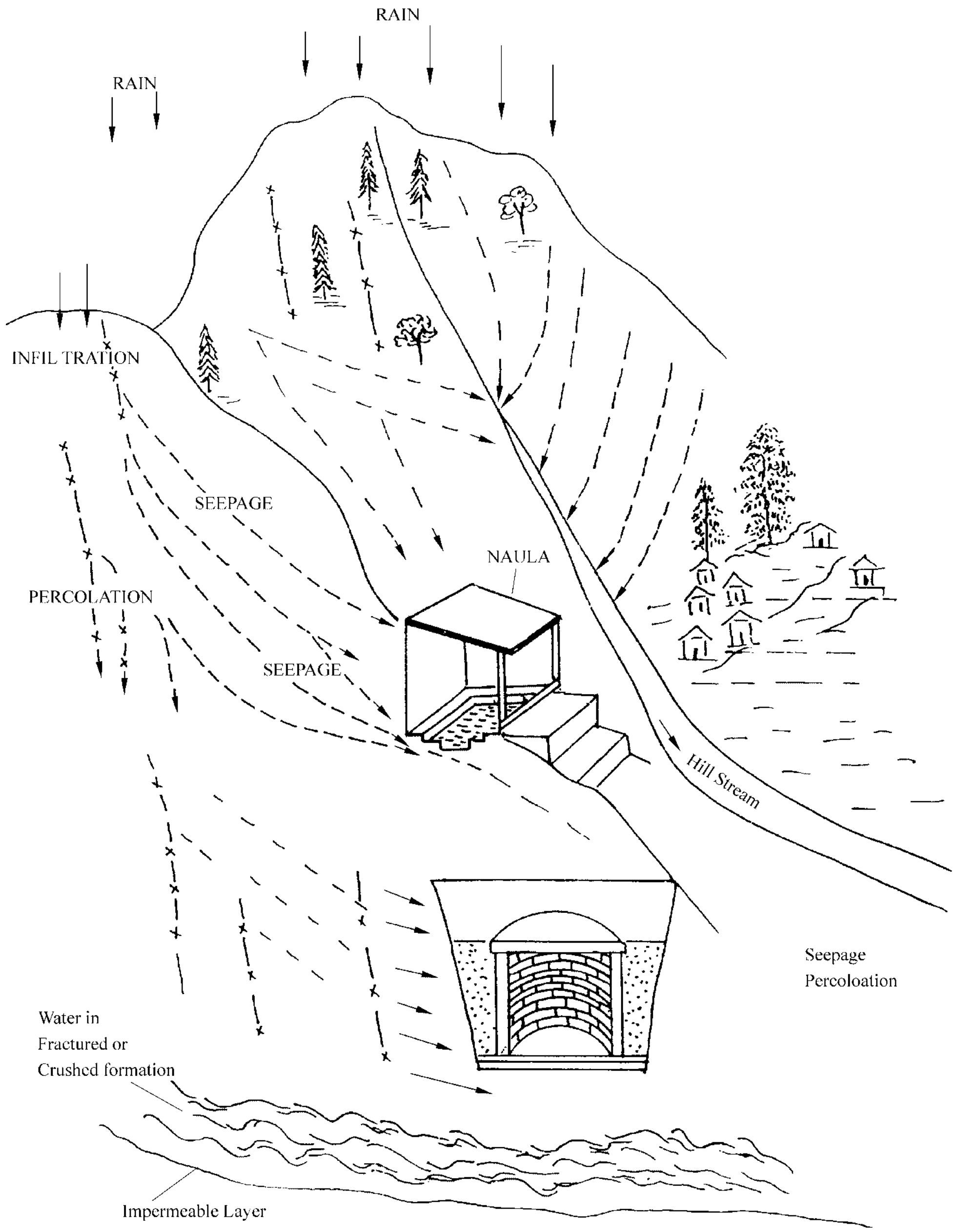

Fig.1 Conceptual Illustration of Infiltration, Soil Water, Seepage, Percolation and Springs Feeding Naula and Infiltration Well

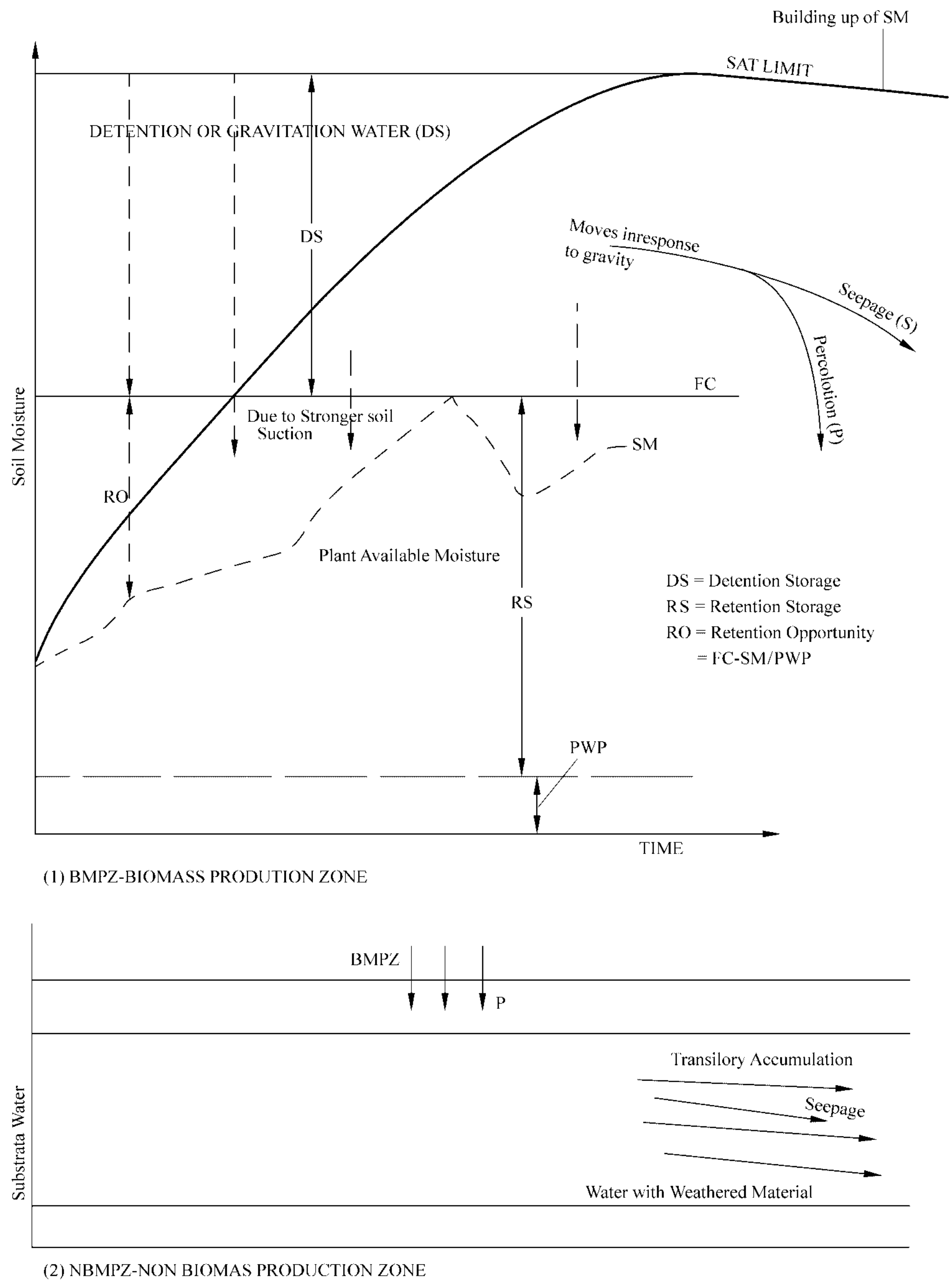

Fig.2 Soil Moisture (SM) Storage: Characteristic and Disposition and water in soil sub-strata

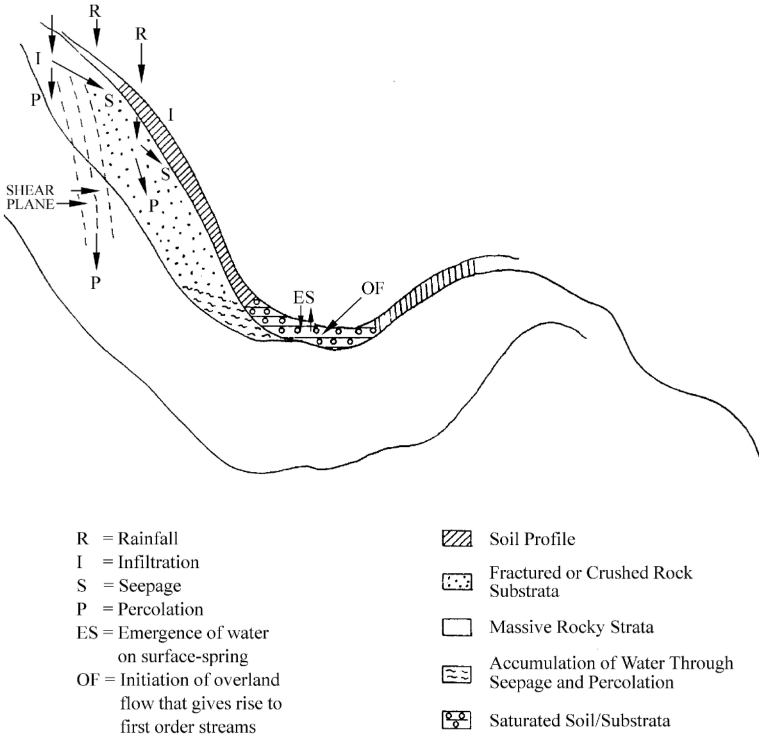

Fig.3 Schematic Presentation of the Generation of a Spring and Rise of first order streams

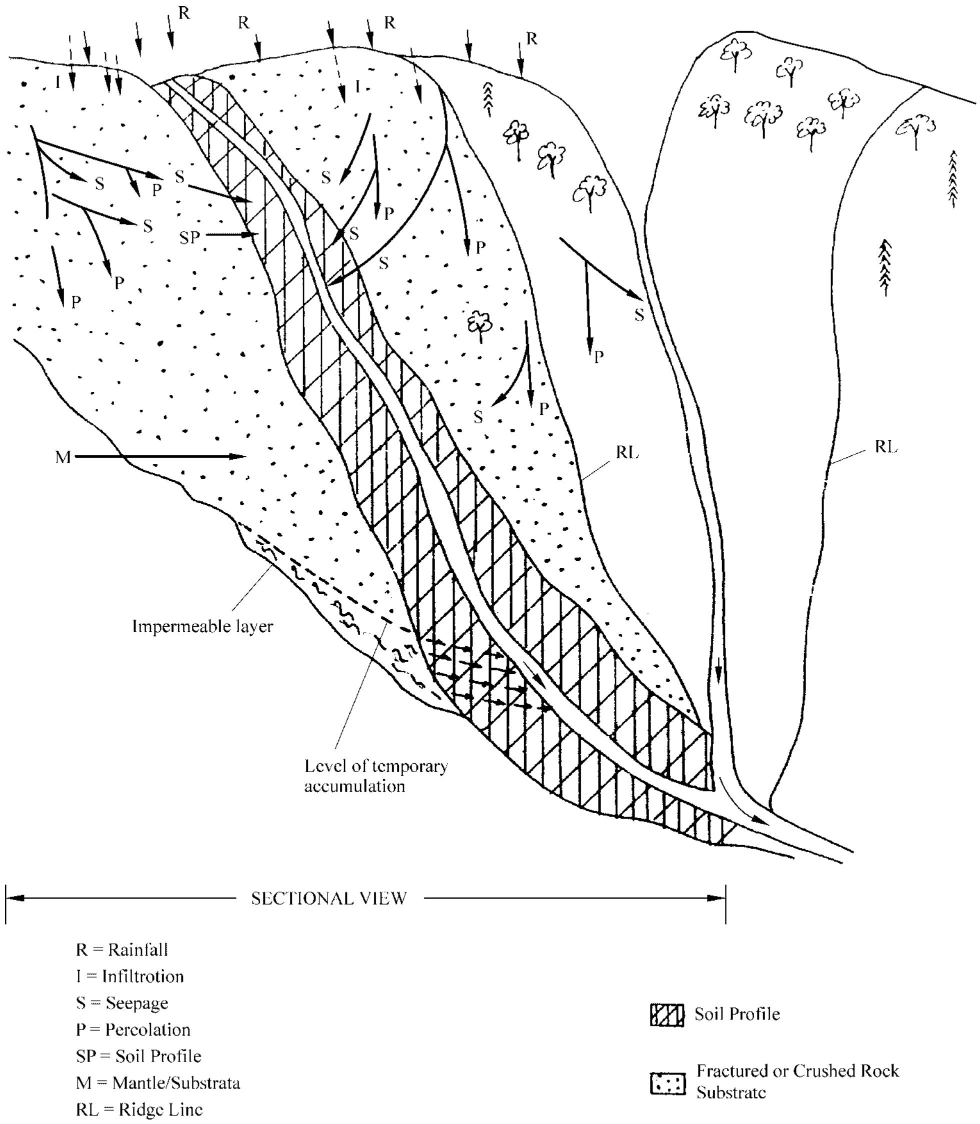

Fig.4 Conceptual Diagram showing direction of Flows that Constitute Seepage & Percolation

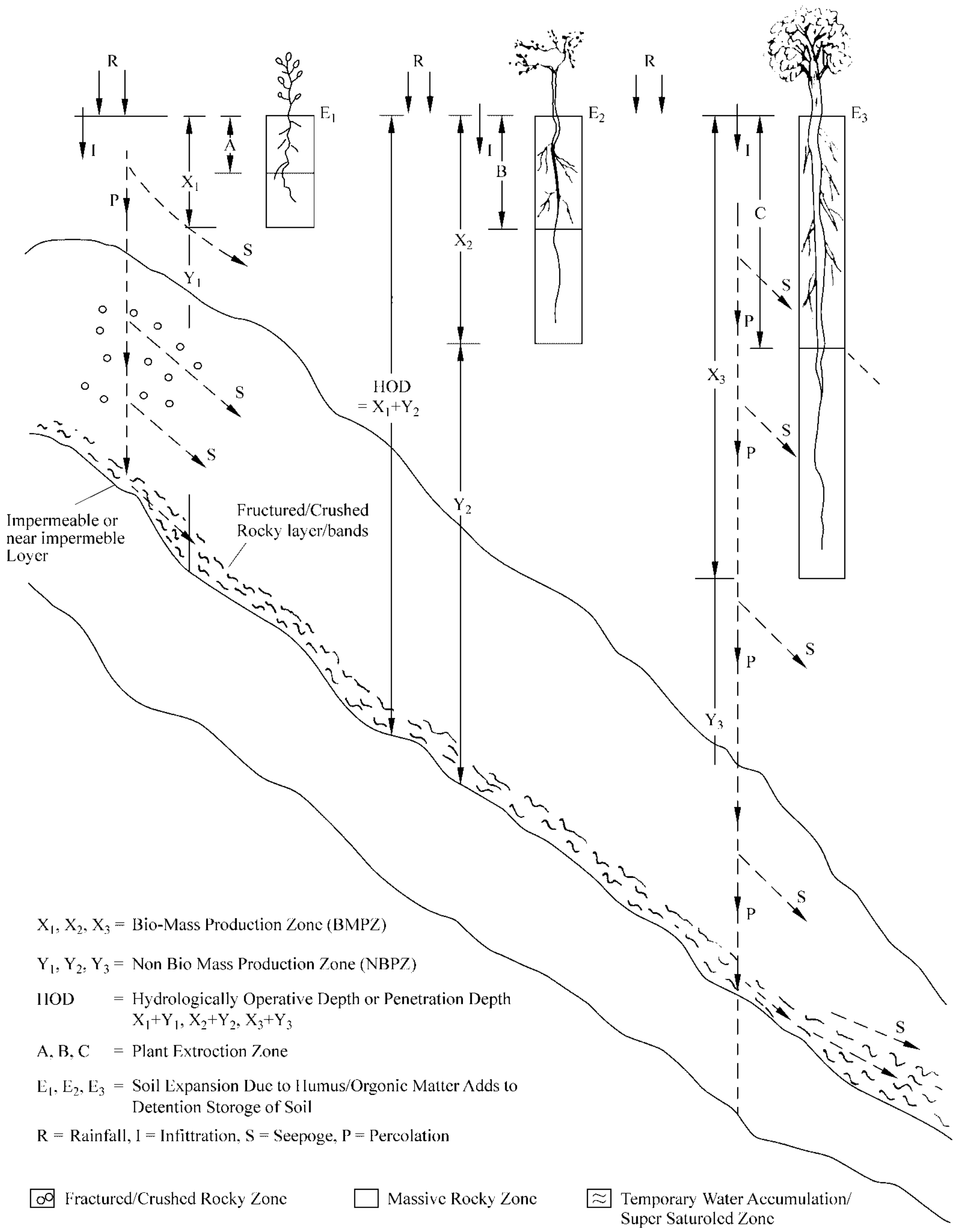

Fig.5 Schematic Illustration of Hydrologically Operative Depth with BMPZ and NBMPZ under different cover conditions on land surface