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Scope of Groundwater Table Studies in the Mountainous Forested Areas

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SCOPE OF GROUNDWATER STUDIES IN MOUNTAINOUS FORESTED AREAS

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INTRODUCTION

There are much misgivings outside the hydrological discipline on the location and behavior of the mountainous water table under forest vegetation and there are many conflicting assertions about the depth of the tree rooting and water table and its seasonal fluctuations. The real concern is whether the two are effectively related or not. Some of the observations indicates that the fluctuations in water table are due to movement of water for irrigations or rural use and lesser recharge from sub soil layer which causes a depression of the water table for a sizable area around. Some times rural people tap aquifers which are for below the superficial water table with which plant roots are associated. The most tenable hypothesis could be drawn that the tap roots of trees are not the major absorber of water from water table In low lying area. However, where the superficial roots system comes in contact with the capillary fringe of water table direct absorption could be possible.

The effects of forest on mountainous around water have not been studied in detail but whatever limited studies have been done indicate non coherent results. While the American studies claim the collapsing of water table as a result of deforestation or forest fire. the Swiss studies seem to indicate no effects on water table when a forest stand changed to grass land (Hamilton & King, 1983). According to Samrai (1984) plantation of Eucalyptus tree in Nilaris resulted in significant lowering of base flow. There exists some data which indicate shallowing of water tables following forest clearing (Bouqhton, 1970) due to replacement of deep rooted trees which were able to use soil moisture at depth by shallow rooted annuals. A study on ground water regime under E.glabucus was therefore conducted at Forest Experimental Watersheds, Osamund and paymund, Nilgiri District of Tamilnadu (Mathur and Raj, 1980) with the objectives of :

1. Establishing a relationship between forest cover (both natural and man-made) and hydrological behavior of watersheds under different climatic and edaphic conditions and to study the effect of silivicultural operations on various components of hydrological cycle.
2. Measuring the effect of forest cover on groundwater table and the effect of large-scale affòrestation on groundwater regime.
3. valuating the effect of vegetation on soil loss and effect of different

silivicultural systems on the water quality.

4. Correlating atmospheric precipitation with vegetal cover & stream flow.

5. Establishing Bench mark Wateresheds in different forest types and evaluating hydrologic behavior of undisturbed forest ecosystems.

WATERSHEDS CHARACTERISTICS

The Forest Experimental Watershed I was located at an elevation of 2134 m with longitude 76°37'15" E and latitude 11°26'10" N. The Forest Experimental Watershed II had an elevation of 2210 m, Longitude 76° 40'E and Latitude 11°24'30"N.

The experimental watersheds had first order streams with simple geomorphological features with minimum depressions and swamps, necessary for minimising difficult storage problems. The watersheds had similar aspects to ensure uniform soil moisture conditions. The selected wateresheds were surveyed and topographical maps prepared in order to arrive at catchment area, watershed shape, topography, drainage pattern etc, Topographic maps were prepared by taking spot levels at nodes of 10 m x 5 m grids. The salient features of the forest Experimental Wateresheds are shown in the table below.

Watershed		Catchment area, ha	Gross slope, %	Vegetation percent
I.	A	3.55	26	Pinus patula 60% Grassland 20% Shola 15% E.globulus 15%
	B	6.83	18	E.globulus 5% Natural Shola 5% Grassland 90%
	C	7.50	20	E.globulus 80% Natural shola 10% Grassland 10%
	D	6.56	18	E.globulus 60% Grassland 30% Natural shola 10%
	K-II	1.15	23	Pinus patula 100%
	CH	-	20	E.globulus 100%
II	P	27.83	10	Pinus patula 80% E.gloobulus 10% Citisus Scoparius10%

CLIMATIC PARAMETERS

A fulfledged Weather Station was installed in the Forest Experimental Watershed, Osamund. Recording and Non recording Rainguages, maximum and minimum Thermometere, Wet and Dry bulb thermometeres, Anemometers and wind Vane, Open pan Evaporimeter and Recording Evaporimeter, Sunshine Recorder, Soil Thermometers, Hydrograph and Therrmograph have been installed as per the specifications of the India meteorological Department.

A small Weather Station was established with Recording and Non-recording Rainguages, Maximum and Minimum Thermometers, wet and Dry bulb Thermometers, Hygrograph and Soil; thermometeres. Other important instruments such as Sunshine Recorder, Anemometer, Wind Vane, Open Evaporimeter and grass minimum thermometeres were also installed.

WATER : Measurement of water yield from catchments was done by volummetric methods and measuring structures. The stream-gauging stations at catchments B and C at Osamund and P at Paymund had b been provided with sharp-crested weirs and with Stewvens F-type Water Level Recorders(60 cm 90 V- Notch Sharp Crested Stevens Type F Recorder). The stream flow at other catchment were measured by volummetric methods. At the time of measuring streamflow, the surface water temperatures were also measured using laboratory thermometer. The details of streamflow measurements at the Forest Experimental Watersheds Osamund and paymund are given below.

SEDIMENT FLOW : Reconnaissance methods such as gully transects, spikes with loose fitting washers, bottle caps and painted pressurized cans were employed for measuring erosion. Iron spikes 50 cm long at interval of 10m x 10m were carefully driven until the spikes were in flush with soil surface. Periodic readings of the depth of spikes, exposed above the surface were taken to assess the erosion of land.

The concentration of suspended sediment was measured at periodic intervals and simultaneously the discharge was measured. The amount of suspended sediment transported was the product of the concentration and discharge. Suspended Sediment concentration was determined by filtration method using filter paper as funnel. In this method the sample was filtered through a filter paper, contents were dried and weighed. Sediment concentration was computed as the ratio of net weight of sediment to the total volume of suspension.

MEASUREMENT OF GROUND WATER LEVELS : With primary aim of providing adequate data to evaluate the effect of vegetation on charge in groundwater storage, a network of observation wells were established in the forest Experimental Watersheds Osamund and paymund under different vegetative covers. Direct measurement of groundwater levels in observation wells were done manually or by automatic recording instruments.

Manual method involved lowering of electrode to water level. Contact with water closed the circuit and indicated by warning light, buzer or deflection in the meter. For continuous recording of groundwater levels, float actuated Sevens F type Water level Recorders were used. While observing groundwater levels, temperature of ground water were noted using laboratory thermometer.

MEASUREMENT OF SOIL MOISTURE : Soil moisture profile studied were conducted regularly in the Forest Experiment Wateresheds, for water balance computations. Soil moisture percentages were observed at depths of 7.5, 15,30, 45, 60, 75, 90, 120, 150, 180, 210, 240, 270, 300 cm below ground level. Weight method and Neutron method were employed for measuring soil moisture. Weighed method involved collecting soil sample, weighing the sample before and after drying, and calculating its moisture content. Initial weights were taken in the field immediately after collection and final weights taken in the laboratory, Ordinary posthole augers (5 cm dia) was used for collection of soil samples.

Neutron scattering method is a rapid means of making in-situ measurement of soil moisture. The principle of neutron method is based on the measurement of hydrogen nuclei that are present in a unit volume of soil, their number being a direct function of water molecules contained in that same volume. This measurement was made by inserting of source of fast neutrons and by counting the slow neutrons produced. The neutron moisture meter consists of a probe which is lowered in the accesas tube inserted vertically in the soil and which contains a source of fast neutrons (American and Beryllium) and a detector of slow neutrons. The instrument used was Troxler (U.S.A) make which has a microprocessor for on the spot calibration of slow neutrons with volummetric soil moisture content. Electrical resistance method and Tensiometer method were also used. The soil moisture profile studies were conducted under various vegetative covers such as Eucalyptus globulus, pinus patula, natural shola forests, grassland etc.

MEASUREMENT OF INFILTRATION : Measurement of infiltration was done using concentric ring infiltrometers in which head of water is built up over the soil. The concentric ring infiltrometers were made of two concentric rings the inner one is with 30 cm dia and outer ring is with 45 cm dia. The inner cylinder was filled up with water to the same height as the inner ring. This was done to minimise the border effect to avoid lateral flow of infiltrating, water beneath the soil column. The rings were inserted into the soil for a minimum depth of 10 cm to prevent leakage. The water level in the inner cylinder was read with point or hook gauge the point gauge was set at desired level to which water was to be added. A stopwatch was used to note the instant the addition of water beings and the time the water reaches the desired level. The difference between the quantity of water added and the volume of water in the cylinder. at the instant it reaches the desired point was taken as the quantity of water that has infilling and first measurement. After initial reading, the point gauge measurements were made at frequent intervals to determine the amount of water that has infiltrated during the time interval. The data were tabulated and the infiltration rate expressed as cm per hour.

MEASUREMENT OF INTERCEPTION : Interception loss was the part of rainfall, retained by the aerial portion of vegetation and is either absorbed by it or returned to the atmosphere through evaporation. Throughfall is the part of rainfall that reaches the ground directly through vegetative canopy, through inter shrub spaces in the canopy and as drip from the leaves, twigs and stems. Stem flow is that part of rainfall that, having been intercepted by the canopy, reaches the ground by running down the stems. Gross rainfall is the total amount of rainfall as measured in the open or above the canopy. The stem flow was collected through a collar fixed at breast height. For measurement of throughfall, collection of entire quantity was difficult, cumbersome and expensive. The throughfall was sampled using rainguages and troughs.

WATER QUALITY STUDIES : As part of programme to study the effect of vegetation of surface and groundwater quality. pH of ground and surface water from areas under different vegetative cover were monitored using portable digital pH-meter. Ground and surface water samples were collected from different observations wells and streams in the Forest Experimental Watersheds, and the pH of water samples were determined in the field immediately after the collection of water samples.

MEASUREMENT OF GROUND COVER : Ground cover protects the soil from direct impact of rain drops and prevents the soil particles being lifted. there exists direct relation between splash erosion and ground cover. A simple method was used to measure the ground cover. A canopy frame was made using conduit pipe of one meter side. The frame was divided into 100 equal squares by fixing wires of 6 gauge 10 cm apart both ways. The frame was placed where canopy measurements were desired and percentage of canopy was counted by eye judgement.

MEASUREMENT OF MICROCLIMATIC PARAMETERS : As part of programme to study the effect of vegetal cover on microclimate, measurement of Relative humidity at a number of points in open, edge of forest and in the middle of forest were done. Assman psychrometer was used for measurement of humidity.

RESULTS

Before plantation the area was covered with a thick mat of natural grass, typical of the woven lock downs and consisted of Chrysopogon Zeylenicus. Androponon polyptychen, Themeda triandra etc. In low lying pockets some shola forests also exist. The area was planted in 1958 with Eucalyptus globulus and coppiced in 1968 after which coppice shoot up. There were 4097 tree planted in the catchment with an average spacing of 2m x 2m. The average height of the tree was 12 m and average D.B.H. 9.5 c.m. for main coppice shoot and 6.7 cm for secondary coppice shoot. Soil water levels in the watershed was measured through the piezometric holes of 7.5 cm diameter made with the help of soil auger and then tops protected by masonry structures. The depth of the ground water table at all these points were measured daily using electronic water level indicator. The average minimum depth of water table was measured as 1.519 m in December and maximum of 6.204 m in March . The average fell in the water table was 1.3 m . Since the recorded water levels was below the root zone of Eucalyptus globulus. it was felt that the root system has not absorbed moisture from the around water table for physiological functions. However in the low lying areas where the water table was higher and very close to the root zone the tree roots might have reached the capillary fringe to absorb moisture and utilize it for physiological activities with better growth performance since the roots have the capacity to utilize water through capillary fringe during period of scarcity and from the stored water of upper soil layers during excess availability.

In order to evaluate the effect of eucalyptus globulus on around water two small natural watersheds, predominantly under blue gum and under grass were selected. A network of four wells in the grass land catchment and a network of six wells in the blue gum catchment in these watersheds were established and the level of water in these wells monitored. The average water level in the catchments has been given in table 1 . analysis of which shows that the water table rose to maximum in July/ August due to monsoon rains and gone to lowest in the month of May/June . It was observed that there was a fall of 29 cm in the water table in grassland and 70 cm in Blue gum.

A longterm hydrological study to assess the effect of blue gum plantation on water yield from catchment was also conducted in Nilgiris (Sharda et. al 1987). Two identical catchments consisting of grass. sholas and swamps were selected in which one was kept at control and the other planted with blue gum. It was found that raising of blue brought significant reduction in the total run off during the first rotation of 10 years. The reduction amounted to 867.74 mm for the entire rotation of 10 years and 67.00 mm for one year which was 165 less than open grass lands. No significant difference was observed in soil moisture level during first five years There was a lowering of soil moisture in eucalyptus catchment during the second five years period The eucalyptus extracted water mainly from upper soil layers (50 cm depth) where as the deeper soil layer remained unaffected. The data on the water table fluctuations did not reveal any significant difference in ground water depletion where as the data on water table fluctuations were found significant at 1 percent level. It was inferred that blue gum has affected the water level in the swamp during lean periods and during the second half of the first rotation (10 years) when they had maximum height and DBH In order to study whether eucalyptus exhibits the phreatophytic characteristics by way of obtaining water freely from the water table for the water table for maximal transpiration and to demonstrate whether there is a direct abstraction or otherwise by the eucalyptus tree from the water tables deeper than 1.5 m.

A study was conducted in the eucalyptus plantation of 1970 (after first coppicing) in, Tarai East Forest Division (U.P) (Reynolds et al., 1987). For this purpose a transact of 3 km at an inclination of 6m/km was selected and at approximately equal distances ten locations boring wells of 15 cm diameter were marked. At the each bored well stevenson water level recorder was emplaced and observations recorded for one or two days along with manual measurement two to three times between 0900 1800 hrs what ever possible the depth of the water table was simultaneously assessed with the help of resistivity meter. The above study indicated that in the case of wells with deeper water table (where the water table was out of range of the roots) maximum rate of rise was in the late afternoon or early evening, whereas maximum rate of fall of the water table was after the mid night (Table 2) The water table was therefore at its shallowes early in the night and deepest in the forenoon. It seemed that fluctuation was out of phase with direct abstraction in these cases, perhaps because of transmission through a capillary zone above the water table. However in case of wells which have shallow water table with superficial root system in contact with capillary fringe the diurnal fluctuation was in phase with the expected course of transpiration through the day and caused by the local absorption of water by tree root. It was thus evident from the above that the rooted hybrid eucalyptus trees had difficulty in reaching the water table in most of the areas. The limited annual fluctuations of the water table in adjoining area as given in table 3 also suggested that the relation of the roots to the water table was not seasonal. Roots could have easily gone downwards with the falling water tables even if they were unable to survive beneath it when it was shallow. Thus the most enable hypothesis was that the taproot of eucalyptus was not a major absorber of water from the water table but if the capillary fringe of the water table had been shallower than 1.5 m than the water absorption could have been possible by the roots.

Water samples collected from piezometric holes, drilled in grass land, natural shola forest and Eucalyptus globulus plantations in the high hill of Nilgiris (the depth of holes were 5.11 and 8m respectively , Mathur et. al 1984) show that there was no significant effect effect on ground water pH due to vegetal covers (table 4). Views expressed that large scale plantation of eucalyptus globulus in Nilgiris causes adverse effect on the quality of ground water was not substantiated by this study and on the contrary proved no adverse effect on ground water pH due to blue gum plantation although the area contained heavy leaf litter in partially or highly decomposed stage. A very minor seasonal variation in ground water pH due to blue gum plantation although the area contained heavy leaf litter in partially or highly decomposed stage. A very minor seasonal variation in ground water pH was however, noticeable in rainy and dry seasons in three types of vegetation, with pH decreased in rainy season than in the winter seasons this is a contradiction with the findings of Reynolds et al (1987) in Tarai area of U.P. where minor increase in pH of ground water was found after the rainy seasons. However, the differences in both the cases were non significant and no inference could be drawn except addition of certain ions to the groundwater by the sub surface flow from higher gradients.

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TABLE 1. AVERAGE LEVEL OF WATERTABLE(M)

	Grassland		Bluegum	
Year	May/Jun(m)	Jul/Aug(m)	May/Jun(m)	Jul/Aug(m)
1980	118.68	121.68	182.90	185.43
1981	118.60	121.21	182.51	185.25
1982	118.33	120.95	182.20	185.03
1983	117.82	120.85	180.80	185.13

Average recharge and depletion of ground water table between May/June and July/august

Year	Recharge	Depletion	N.Fall	Recharge	Depletion	N.Fall
1980	2.39	2.47	0.08	2.53	2.92	0.39
1981	2.61	2.88	0.27	2.74	3.05	0.31
1982	2.62	3.13	0.51	2.83	4.23	1.40
Mean	2.54	2.83	0.29	2.70	3.40	0.70

TABLE 2. RECORD OF WATER LEVEL IN TARAI AREA(U.P.)

Depth of watertable(m)		Rise(r) or Fall(f) in 24 hrs (mm)	Time of deepest watertable(hr)	Time of shallowest watertable (hr)
1.67	2.45	f1.5	1200-1430	1900-2400
2.14	2.49	nil	1230-0710	0130
1.40	1.97	r1.0	1500-2800	rising
1.62	1.85	nil	1700-2200	1100
2.41	2.95	r25.0	-	-

TABLE 3: MEAN MONTHLY WATER TABLE OF THE AREA

Location	Month	Maximum depth(m)	Month	Minimum depth(m)
	June	9.3	April	8.4
	August	9.3		
I	September	9.3		
	November	9.3		
	December	9.3		
II	July	4.4	September	4.0
	May	1.2	October	4.0
	June	1.2	August	0.5

TABLE 4. AVERAGE pH OF GROUND WATER DURING MONSOON AND NON-MONSOON

Season	Grass	Shola	Eucalyptus globulas
Monsoon	5.9, 5.9, 5.4	6.2, 5.9, 5.6	5.9, 5.6, 5.9
Non-monsoon	6.0, 6.9, 6.7	6.3, 6.3, 6.7	6.2, 6.3, 6.3

TABLE 5: THE pH OF GROUND WATER BEFORE AND AFTER MONSOON IN TARAI AREA IN EUCALYPTUS HYBRID PLANTATION

Before monsoon (May)	After monsoon(Oct.)
6.78	7.24
6.50	7.65
7.10	8.86
6.97	7.91
6.35	7.33
6.95	7.50
7.11	7.91

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