

SESSION-2 :

SNOW MELT, RUNOFF, FLOW MODELING

SNOW AND GLACIER MELT CONTRIBUTION IN UPPER PART OF BHAGIRATHI RIVER, WESTERN HIMALAYAS, INDIA USING ISOTOPIC TECHNIQUES

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ABSTRACT

The snow and glacier melt runoff contributes significantly to almost all perennial rivers all over the world. In India particularly the Himalayan rivers receives the snow and glacier melt contribution during summer when demand of water increases for hydropower, drinking and irrigation etc. Due to lack of information of the assured availability of melt water, water resources management policies/project at lower reaches of the glacier fed rivers are often formulated without considering the impact of snow and glacier on river hydrology. Despite of its importance, very less information are available for snow/glacier melt contribution in river flow in head water catchment, mainly due to inaccessible and difficult terrain. Therefore, it becomes essential to understand the contribution of snow and glacier melt to the river in headwater region for better management of river and river based project. But it is difficult to segregate the different component of river discharge using the conventional techniques due to lack of required data from this inaccessible terrain.

Hence, an attempt has been made in the present study to understand the stream flow generation processes in upper part of Bhagirathi River a tributary of River Ganga using isotopic techniques. Monthly water samples of precipitation, river, springs, snow and glacier melt were collected during 2004 and 2005 and analysed for stable isotopes such as $\delta^{18}\text{O}$ and $\delta^2\text{H}$. Isotope results show that the snowmelt, glacier melt, direct runoff and the sub-surface flows have distinct stable isotopic signatures and their relative contributions to the total stream flow vary with climatic conditions. The melting of snow starts from the lower altitude during February, followed by melting of glacier (i.e. during June, July and August) which continues till October. Direct runoff generates peak flows during rainy season and the subsurface flows sustain the Bhagirathi River during the lean flow periods in winter and summer. Two and three component mixing models (using $\delta^{18}\text{O}$, and electrical conductivity) were used for partitioning the stream flows on a monthly basis at Dabrani site during 2004 - 2005.

It is found that direct runoff from precipitation accounts 18% to 49% of the total river discharge during the month July and September of the year 2005 which on average is ~26% of the total annual flow. The maximum contribution of

snow/glacier is in the month May which is 64% of the total stream discharge. The total melt runoff during the ablation period of 2005 is estimated to be ~40% at the Dabrani site. The subsurface contribution ranges from 24% in monsoon season to ~100% during winter. The total contribution from subsurface during a year comes out ~34% of the total Bhagirathi river discharge.

Therefore, isotopes can be used as a potential tool for the better management of river and understanding the contributions of different water sources, namely, rain, snow and glacier to river in a Himalayan catchment during different months.

SUITABILITY ANALYSIS OF RUNOFF METHODS

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ABSTRACT

Water is not only a basic need but also a prime natural resource and a precious asset. Large percentage of population of India is dependent on rainfall for fulfilling its water requirement throughout the year. This dependence has increased to a higher level due to the continuous fall in the groundwater table. The runoff available in a river basin after rainfall of a particular intensity is of high importance both for the planners as well as people responsible for manage the water available.

In the present paper, data from five catchments spread over Banas river basin in Rajasthan have been analyzed to compare the runoff as calculated by various methods. It is found that the average error in predicted rainfall is minimum for rainfall-runoff coefficient method. This method can be used for small to medium size catchments. This is followed by Strange's Curve method, which can be applied if rainfall-runoff observations of similar catchments is available. Further, Lacey method is found to be suitable only for rainfall of standard duration whereas Inglis formula is suitable only for small catchments, which have heavy rainfall.

VARIABLE PARAMETER MUSKINGUM-CUNGE METHOD: A POWERFUL TOOL FOR OVERLAND FLOW MODELLING

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ABSTRACT

Overland flow is an important component of the hydrological process by which the precipitation fallen on the land surface is transported down the slope as a sheet flow before draining into different form of the stream, and is influenced by the dynamic interaction between the spatially and temporally varying climatic and physiographic factors, such as rainfall, infiltration, ground cover, land use, soil and topography. Accurate overland flow simulation is essential for addressing variety of hydrological and environmental problems such as flood estimation for design of hydraulic structures, flood regulation, design and management of agricultural drainage systems and urban storm water systems, soil erosion control, waste water management, hydrologic responses to land use and land cover changes, land-atmosphere interaction, hydrologic forecasting etc.

The main objective behind the simplified overland flow routing method development is the ability of the method to offer a numerical stability, mathematical simplicity, minimal input data requirement, and flexibility in the use of coarse computational spatial and temporal grid size without compromising its accuracy as compared to the full dynamic methods. Variable Parameter Muskingum-Cunge (VPMC) channel routing method is a very useful tool for the purpose of accurate channel flow routing considering the channel cross-sectional and flow characteristics. The VPMC method is also incorporated into number of software packages used for prediction of the stream flow runoff, sediment transport studies and catchment modelling. In the present paper, an attempt has been made to verify the capabilities of the VPMC method for overland flow modelling using the Izzard's experimental data while comparing the simulation results with those by the full Saint-Venant solution. This paper also attempts to bring out the advantage as well as limitations of the method for its potential use in catchment modelling studies. Once integrated with user-friendly GIS capabilities, the VPMC method would offer a great potential as a simplified overland flow routing method as a component model of the integrated catchment model developed for climate change studies.

RAINFALL-DISCHARGE RELATIONSHIP OF ARNIGAD AND BANSIGAD MICRO-WATERSHEDS IN MUSSORIE

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ABSTRACT

A study was carried out to compare hydrological regime of two micro-watersheds having dense oak forest with a degraded oak forest. These micro-watersheds are located at Arnigad and Bansigad (Mussoorie, Uttarakhand). Both climatological and hydrological parameters were determined. In Arnigad, monthly minimum temperature ranges from 6°C to 19°C for both the years (March 2008- Feb. 2010) and monthly maximum temperature ranges from 17°C to 30°C. In Bansigad, monthly minimum temperature ranges from 4°C to 18°C for both the years (March 2008- Feb. 2010) and monthly maximum temperature ranges from 13°C to 28°C. The monthly rainfall varied from 0 mm to 1136 mm for the first year (March 2008- Feb. 2009) and 0 mm to 778 mm for the second year (March 2009- Feb. 2010) in Arnigad. For Bansigad, monthly rainfall varied from 0.9 mm to 1008 mm for the first year (March 2008- Feb. 2009) and 0 mm to 961 mm for the second year (March 2009- Feb. 2010). Discharge declined slowly in Arnigad stream during post monsoon months while it declined at a faster rate in Bansigad stream. Stream at Bansigad got dried up completely in summer months. Average discharge in Bansigad for the first year was found to be 0.101m³/sec and it was 0.022m³/sec for second year. In Arnigad, average discharge was 0.139m³/sec for the first year and it was 0.092m³/sec for the second year. Preliminary results indicated that dense oak forests exerted a positive influence in regulating the flow of water.

STUDY OF FRICTION FACTOR AND CONVEYANCE AT MAHUWA GAUGING STATION OF PURNA RIVER OF SOUTH GUJARAT

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ABSTRACT

The friction factor of an open channel flow is generally affected by the characteristics of the fluid, flow, Geometry of the channel and the characteristics of the channel boundary. Large research has been carried out for the study of friction factor using one or more parameters like Froude number, Relative flow depth, hydraulic mean depth, slope, flow Reynolds number, size of the particles etc. However, in each study only limited numbers of the parameters has been considered. In alluvial rivers depending upon the flow conditions any of the above parameters may vary and predominate to change the friction factor. So, here the attempt has been made to compute the friction factor following the different methods and approaches based on the field data of Purna river and study the variation of conveyance with friction factor. The mathematical model to predict the friction factor for the Purna river at Mahuwa Gauging station has been developed by using the average value of the friction factor obtained by various methods and approaches and the multiple regression analysis.

STUDY OF RAINFALL RUNOFF RELATION BY REGRESSION

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ABSTRACT

There is a pressing need to improve capability to predict the hydrological responses of the catchments where only rainfall and runoff data is available. The literature indicates that physically-based rainfall-runoff models are not able to meet this challenge. Simple empirical or semi-empirical models may perform equally well or better than the physically-based model and provide basic but important information into catchment functioning. Rainfall- Runoff relationships are obtained through the application of regression analysis in many studies. Since the rainfall and runoff measurements show haphazard fluctuations around an average value, the appropriate methodology need to be based on uncertainty techniques such as conventional statistical approaches.

In this context, daily data of rainfall and runoff from 2003 to 2007 in Lakhandur, a 12000 km² catchment in the Bhandara district of Maharashtra, is analysed using regression method by Hydrology modeling software HYMOS. Runoff depths are regressed against areal rainfall of the five raingauge stations in and around the catchment for daily data. Statistical methods were used to obtain the least-squares multiple linear regression equation, correlation coefficient, and the standard error for linear, polynomial, logarithmic, hyperbolic and exponential relationships for the catchment. Simple multi-linear relationships between runoff depth and rainfall have generated the best predictions, and robust prediction confidence limits.

The multi-linear relationship is investigated further by adding a variable of each preceding day rainfall in the regression equation till the preceding rainfall is upto seventh day. As such eight relations were analysed wherein the statistics of each relation was studied. The statistical values of coefficients and constant for the regression equation, R^2 , Standard error for the y-estimate, standard error values for the coefficient, the F value, degree of freedom, etc were worked out. It was observed from the analysis of t & p- values that increasing the number of variables in the multi-linear equation improves the R^2 and standard error values slightly but three coefficients i.e. rainfall with two previous days' rains are competent enough to correlate the rainfall runoff relation. Apart from areal rainfall, the antecedent moisture content and infiltration can thus be taken care of without actual assessment of the same.

STUDY OF FLOW RESISTANCE AND ITS RELATION WITH DISCHARGE AND SHEILD ENTRAINMEN FUNCTION FOR AMBIKA RIVER OF SOUTH GUJARAT

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ABSTRACT

The friction factor of an open channel flow is generally affected by the characteristics of the fluid, flow, Geometry of the channel and the characteristics of the channel boundary. Large research has been carried out for the study of friction factor using one or more parameters like Froude number, Relative flow depth, hydraulic mean depth, slope, flow Reynolds number, size of the particles etc. However, in each study only limited numbers of the parameters has been considered. In alluvial rivers depending upon the flow conditions any of the above parameters may vary and predominate to change the friction factor. So, here the attempt has been made to compute the friction factor following the different methods and approaches based on the field data of Ambika river and study its variation with Sheild entrainment function and flow discharge. The mathematical model to predict the friction factor for the Ambika river at Gadat Gauging station has been developed by using the average value of the friction factor obtained by various methods and approaches and the multiple regression analysis.