ABSTRACT

The predictive capabilities of the distributed parameter Agricultural Non Point Source (AGNPS) and Areal Nonpoint Source Watershed Environment Response Simulation (ANSWERS) models have been studied with respect to runoff, peak flow and sediment yield for a 16.40 km^2 small watershed of Upper Damodar Valley, Hazaribagh district of Jharkhand, India. Precipitation, stream flow runoff and sediment load were monitored for the rainfall-runoff events (storms) of 1993 to 1996. The models were calibrated by using 16 storms of 1993 and 1994 and validated with 15 storms of 1995 and 1996. The watershed boundary, drainage network, watershed and channel slopes, flow direction layers were generated using digital elevation model (DEM) through EASI/PACE and IDRISI GIS softwares. Land use and land cover information with 88% classification accuracy were generated from Indian Remote Sensing Satellite (IRS-1B,LISS-II) data. The major part of the watershed is flat with an average slope of about 1.91 per cent.

Input parameters of the AGNPS and ANSWERS models were generated from GIS data layers containing watershed boundary, DEM, land use and land cover, and soil texture at 60 m and 30 m cell sizes respectively. The underprediction or overprediction of the hydrologic variables within or equal to 20% of the observed values by the models was considered as criteria of success. Statistical parameters such as per cent deviation (Dv), Nash and Sutcliffe's coefficient of efficiency (E), coefficient of determination (R^2), root mean square error (RMSE), index of agreement for difference (IOA-d) and Student's t test for significant difference were used to test the model simulation results. The curve numbers, the USLE C factor and Manning's roughness coefficient (n) were varied were varied according to prevailing watershed conditions for AGNPS model calibration. The AGNPS model predicted runoff, peak flow and sediment yield values close to the observed values for the option of AGNPS method of peak flow computations, geomorphic option for channel variables and K coefficient (K= 484.00) method of hydrograph shape factor. New limits of five day antecedent rainfall and antecedent precipitation index were defined for the classification of the antecedent moisture condition (AMC).

For the AGNPS model validation, the average per cent deviation (Dv) equal to –5.67, -14.17 and –5.68 and the coefficient of efficiency (E) equal to 0.988, 0.907, and 0.964 were obtained for surface runoff, peak flow and sediment yield respectively. The AGNPS model predictions are most significantly influenced by the AMC. Sensitivity analysis of the AGNPS model input parameters revealed that the runoff and peak flow prediction are most sensitive to rainfall amount followed by curve number. The sediment yield prediction is influenced significantly by the field slope (FS), soil erodibility (K)

factor, storm EI, curve number (CN) and cover and management (C) factor variables in descending order of significance. The effect of cell size variation influences the accuracy of watershed parameters extracted from DEM. For AGNPS model, runoff and peak flow simulations are not influenced by the cell size variation from 60 m to 150 m. Sediment yield simulations are influenced by the cell size variation and prediction decreases as the cell size increases. The predictions are within acceptable level upto 120 m cell size.

During ANSWERS model calibration process, the rainfall detachment and flow coefficients equal to the ANSWERS original version values and sediment transport coefficients equal to 10% greater values than ANSWERS original version values simulated sediment yield close to the observed values with an average deviation equal to -3.04%. The optimized value of control zone depth parameter was found to be equal to 50% of 'A' horizon depth. For ANSWERS model validation, the average per cent Dv equal to –8.13, -2.25 and -1.63 and E equal to 0.991, 0.741, and 0.965 were obtained for surface runoff, peak flow and sediment yield respectively.

The sensitivity analysis of the ANSWERS model input parameters revealed that the runoff and peak flow simulation are found to be most sensitive to antecedent soil moisture (ASM) followed by the control zone depth (DF), Manning's n and field slope in decreasing order of significance. The variables significantly affecting the sediment yield in descending order are C factor and K factor, ASM, DF, FS and Manning's n. The cell size variation from 30 m to 150 m influences the prediction of runoff, peak flow and sediment yield. The model predictions for runoff and sediment yield are within acceptable level of accuracy upto 120 m cell size. However, for peak flow, the model simulations are at acceptable limit for 30 m cell size.

The AGNPS model was used to identify the critical erosion prone areas within the watershed on the basis of cell erosion rates and to evaluate the effect of the suggested land use based best management practices (BMPs) on watershed response. About 18% of the watershed area is having soil erosion rate higher than the permissible value which reduces upto 3% and sediment yield is reduced by 71% from present level through implementation of BMP-4 scenario. The AGNPS model is capable for evaluating non point pollution (sediment yield) at any point within a watershed and the effects of alternate land use based management practices on watershed response. Both the AGNPS and ANSWERS models predict hydrological variables for the most of the storms with deviations less than 15 per cent from the observed values, which indicate the suitability of their application for small watersheds of similar hydro-geological characteristics.

Key words : *Distributed Parameter, ANSWERS, AGNPS, Simulation, DEM, GIS, BMPs*