Int. J. Forest, Soil and Erosion, 2015 5 (3):
ISSN 2251-6387

Research Paper

Comparison of WEPP, ANSWERS and MPSIAC models for evaluating the runoff, soil erosion and sediment at Khosroshirin region, Fars province, Iran

Sayed Fakhreddin Afzali [*1], Ensiyeh Baqeri[2], Seifollah Amin[3], Elnaz Namdari Ghareghani[4], Elinaz soltani[5]

1.Faculty member of Natural Resource and Environment Engineering Department, Shiraz University, Iran (Corresponding Author), Email:afzalif@shirazu.ac.ir
2.M.S.c of Water Science Engineering, Shiraz University, Iran
3.Professor of Water Science Engineering Department, Shiraz University, Iran
4.Natural Resource and Environment Engineering Department, Shiraz University, Iran
5.Natural Resource and Environment Engineering Department, Shiraz University, Iran

Abstract: Erosion is a serious threat for water and soil resources. There are various models to estimate erosion and sediment of watershed in the world. In this study, erosion and sediment measurements were done by WEPP model in order to calibrate runoff values for Agriculture college of Shiraz University field then WEPP model was runned for Khosroshirin region in Molasadra dam watershed. Finally, WEPP, ANSWERS and MPSIAC results were compared. Results showed significant correlation among runoff values which were estimated by WEPP and ANSWERS models, that values of R^2 were between 0.9 to 0.98. Statistical test of F-test showed no differences between estimated values of WEPP and ANSWERS models. Result comparisons of WEPP and MPSIAC models showed sediment by MPSIAC model was 5.8 ton/hectare/year and there was significant difference with measured values of sediment evaluation (9.85 ton/hectare/year).

Abstract: Erosion is a serious threat for water and soil resources. There are various models to estimate erosion and sediment of watershed in the world. In this study, erosion and sediment measurements were done by WEPP model in order to calibrate runoff values for Agriculture college of Shiraz University field then WEPP model was runned for Khosroshirin region in Molasadra dam watershed. Finally, WEPP, ANSWERS and MPSIAC results were compared. Results showed significant correlation among runoff values which were estimated by WEPP and ANSWERS models, that values of R^2 were between 0.9 to 0.98. Statistical test of F-test showed no differences between estimated values of WEPP and ANSWERS models. Result comparisons of WEPP and MPSIAC models showed sediment by MPSIAC model was 5.8 ton/hectare/year and there was significant difference with measured values of sediment evaluation (9.85 ton/hectare/year).

Keywords: Simulation, Soil degradation, Watershed , Runoff, Empirical model.

Introduction

Soil erosion is a factor which threats soil and water supply and dealing with this issue is an inventible issue, so it could not be prevented. Human activities could increase or decrease this issue. Some area of soil in Iran are involved in wind and water erosion every year. In regions which soil erosion is not controlled, gradually soils are wearing away and soil fertility is decreased, so gardens will be discarded and this leads to severe damages.

Also, soil sedimentation in channels, storage of stank, ports and decreasing capacity of pools leads to abundant damages. Soil erosion leads to wasting soil nutrition and destroying soil structure which is known as one of big economic, social and environmental problems.

Many efforts have been done in most countries in the world to prevent and control this issue. Soil erosion is increased that is caused by surface runoff (WISCHMEIR, 1978). Erosion and sediment is minimized if any type of application is identified and is done based on scientific principles. In this regard, predicting erosion should be done through sediment evaluation station, but due to limited station empirical mathematical models are used.

Bhuyan et.al,2002, investigated three erosion models like WEPP, ANSWERS AND EPIC to simulate soil loss from three different irrigation systems (ridge-till, chisel-plow, no-till) and calibrated parameters with sensitivity analysis by soil erosion data. Data of soil erosion was collected from an experimental region of Kansas union in USA. Field experiments were done on small plots from 1995 to 1997 to measure runoff and loss of all soils under different agricultural systems.

In 2007, Pieri et al used WEPP model in Apennines Mountains of north Italy. At first, WEPP was used to simulate surface runoff, soil water and erosion and ability of three plants were evaluated to decrease sediment and surface runoff. Results showed in studied region, continuous cropping of corn decrease surface runoff and sediment of soil, but decrease quality of soil.

In 2008, Pandey et al calibrated WEPP model for small watershed in India and did sensitivity analysis on input parameters of the model, results of analysis showed sediment is sensitive to Interrill erosion.

Verma et.al conducted hydrological model of WEPP and HEC-HMS in 2010 using GIS technology in upper region of Baitarani river in east of India. Results showed both models had underestimation during 1999, 2002, 2004 and 2005 and had overestimation during 2001 and 2003, while during 2000 HEC-HMS had underestimation and WEPP model had overestimation. Totally, results showed HEC-HMS model is better to simulate runoff in Baitarani River compared to WEPP model.

WEPP (Water Erosion Prediction Project) is a new generation of soil erosion model which predict soil erosion in place and time scales. This model is applied for small sub- region and small region to evaluate soil erosion per hour, monthly or yearly (Pudasaini et

al., 2004). In this study, WEPP model was used to evaluate floodwater, erosion and sediment in two regions of Fars province and is compared by ANSWERS and MPSIAC models.

Materials and Methods

Study area

In order to achieve goals of study, a watershed with 3.62 hectare (Garousi, 1997) was selected in north west of agriculture college in 15 kilometer of north of Shiraz. Selected watershed is placed in Badjgah lowland. Badjgah region has dry climate. Total percipitation of region which is 401 millimeter average during October to May and in other month climate is dry and warm (Garousi, 1997). The only weather station of Badjgah is placed in agriculture college.

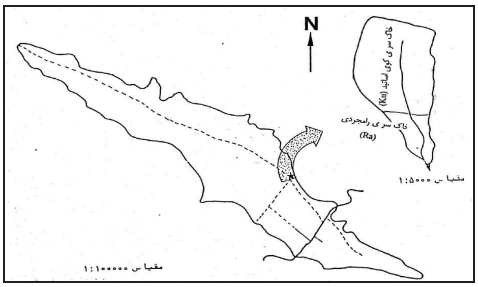

Figure (1): Situation of calibration region.

The Khosroshirin watershed is catchment of Mollasadra dam which is placed in Eastern longitude (52º12´16˝ and 51º49´23˝) and Northern latitude (30º59´34˝ and 30º37´02˝) . This area has 6400 hectares and the average slope is 13.80 % and average of height is 2376.3 above sea level (Rezaeian, 2009). Moisture and temperature regims of studied soils are Xeric and Mesic, respectively. The current land use in form of high-altitude areas are in poor to very poor grassland with canopy cover 7 to 15 percent. In lower parts lands, there is irrigated agriculture and in some part there is rainfed agriculture.

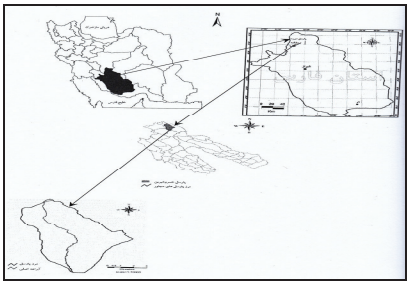

Figure (2): Khosroshirin watershed study area.

Soil series

There are two soil series namely Kuye Asatid and Ramjerdi in Badjgah lowland. Kuye Asatid series soil texture and Ramjerdi Series is Sandy – clay and clay – sandy, respectively. Required data of the model was gathered form Solhi 1988, Momtahen 1989, Garousi 1997 and Rajaei 1995 studies and were replaced in files of model. Weather data were gathered through weather station of Agriculture college.

Methodology

In this study the working unit map obtained from geology and faces maps (Khosrowshirin area was divided into 25 units). Soil texture was measured through hydrometric method. Cation exchange capacity (CEC) and organic matter, and other parameters of soil like Albedo coefficient, rill and inter-rill erosion, critical shear stress and effective hydraulic flow were estimated through functions and inserted in the model. Climatology information of Khosroshirin region was used at climate file. In this file, basic data such as average percipitation, solar radiation and wind speed were gathered in Khosroshirin region for twenty years. Land cover data of Khosroshirin watershed was drawn in the management file. After making different files for calibration region, model was runned and results were measured and compared with ANSWERS and MPSIAC models. Significance of relationships were analyzed by F-test.

Result and Discussion

Runoff, sediment and soil erosion which are estimated by WEPP model are shown for three different rainfall events in west of Shiraz agriculture university and these are compared with estimated values of ANSWERS model (figures. 3-10).

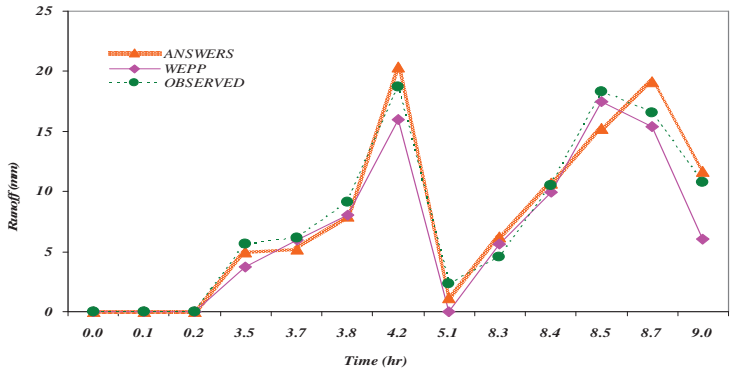

Figure (3): Estimated runoff by WEPP and ANSWERS models and observed value for rainfall on 29.3.1997 in Badjgah region

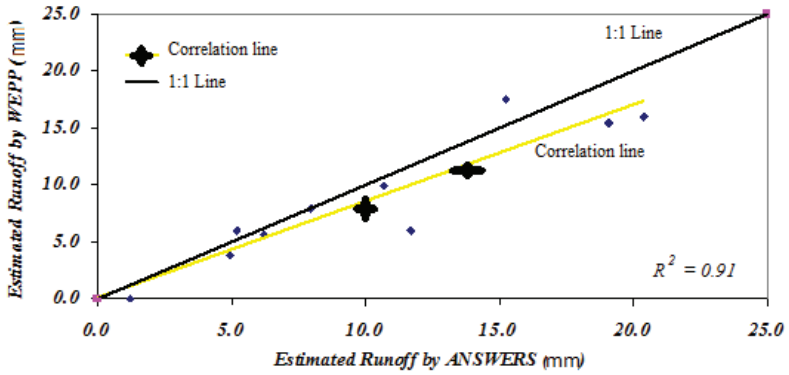

Figure (4) Correlation of estimated runoff by WEPP and ANSWERS models and observed rainfall data on 29.3.1997 in Badjgah region with fitted line.

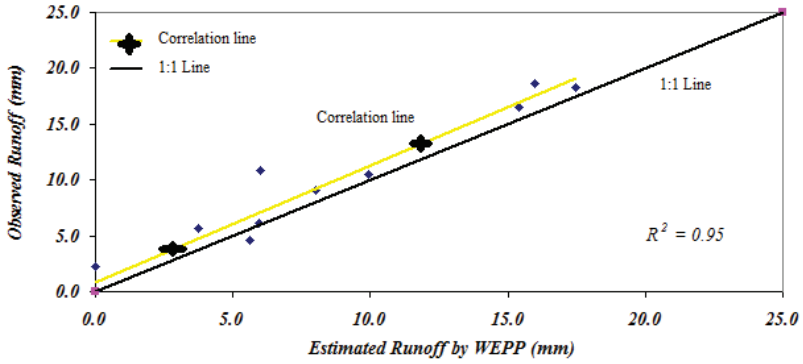

Figure (5): Correlation of estimated runoff by WEPP model for rainfall event on 29.3.1997 in Badjgah region and fitted line.

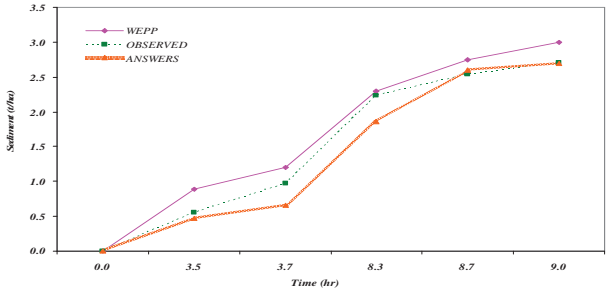

Figure (6): Estimated sediment by WEPP and ANSWERS models and observed values for rainfall event on 29.3.1997 in Badjgah region.

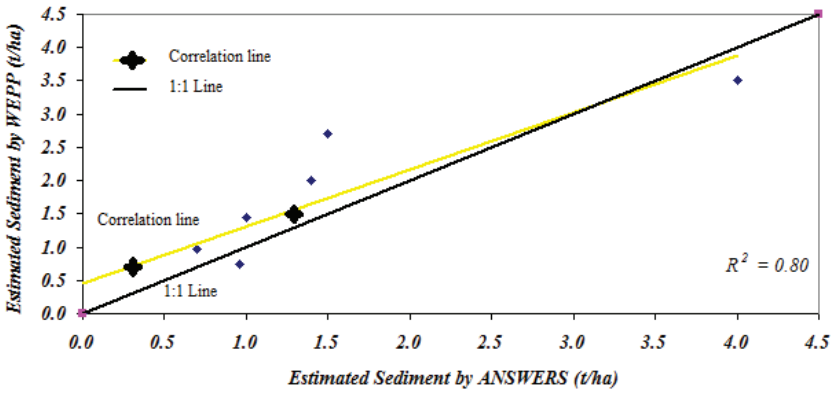

Figure (7): Correlation of estimated sediment by WEPP and ANSWERS models and observed values for rainfall event on 29.3.1997 in Badjgah region and fitted line.

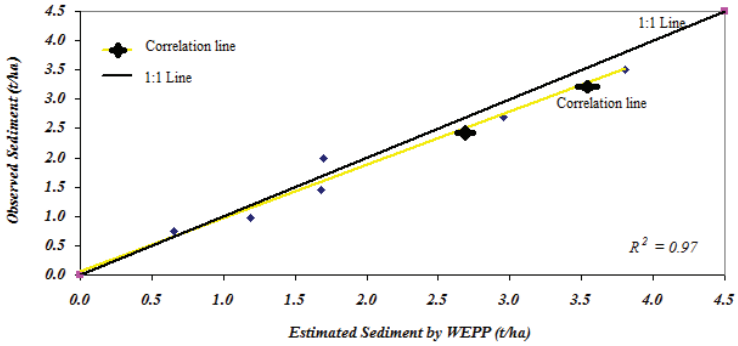

Figure (8): Correlation of estimated sediment by WEPP model e for rainfall event on 29.3.1997 in Badjgah region and fitted line.

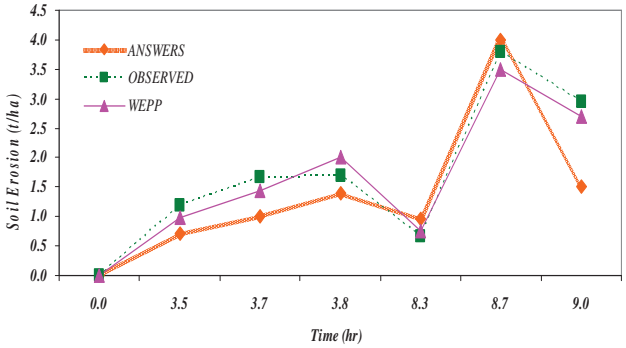

Figure (9): Estimated erosion by WEPP and ANSWERS models and observed values for rainfall on 29.3.1997 in Badjgah region.

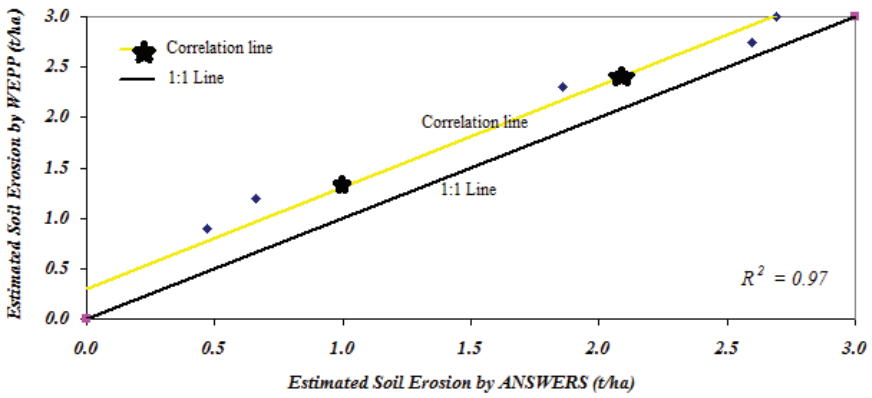

Figure (10): Correlation of estimated erosion by WEPP and ANSWERS models and observed values for rainfall on 29.3.1997 in Badjgah region and fitted line.

Results showed runoff, erosion and sediment estimated by WEPP model fitted well to estimated same values of ANSWERS model which values of R^2 were more than 0.9. Also, between runoff, erosion and sediment estimated by WEPP model and similar estimated values from ANSWERS model there were no significant difference.

Results of Khosroshirin area

Four rainfall events were investigated in Khosroshirin watershed and Wepp results are explained and compared to the results of ANSWERES Model (Table 1 and 2).

Table 1: Runoff values which are estimated by WEPP and ANSWERES models for different rainfall events.

Date	*Runoff by WEPP(mm)*	*Runoff by ANSWERS(mm)*
2.3.1999	*13.37*	*14.44*
21.12.2001	*14.56*	*13.84*
6.12.2003	*16.63*	*17.89*
11.1.2004	*32.31*	*33.92*

Table 2: Erosion values which are estimated by WEPP and ANSWERES models for different rainfall events.

Date	*Soil Erosion by WEPP(t/ha)*	*Soil Erosion by ANSWERS(t/ha)*
2.3.1999	*1.71*	*1.33*
21.12.2001	*1.35*	*1.17*
6.12.2003	*2.12*	*1.61*
11.1.2004	*3.87*	*3.71*

As shown in 11 and 12 and above figures, there are good fited line between results of runoff values by ANSWERS and WEPP models with value of R^2 is more than 0.9. Also, runoff and erosion values by WEPP model and ANSWERS model were compared , so there is no significant difference between WEPP and ANSWERS Model (F-TEST).

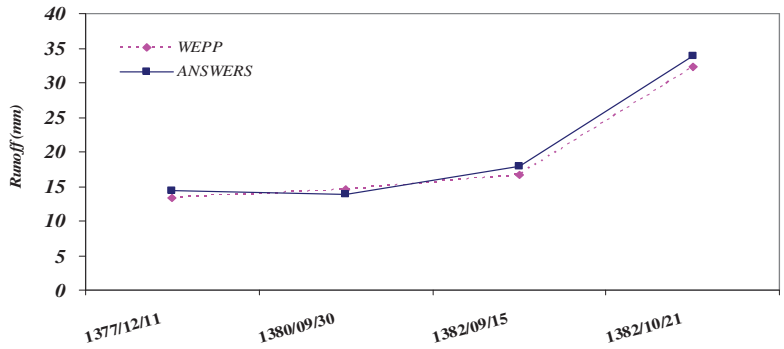

Figure (11): Relationship between estimated runoff by WEPP and ANSWERS models for different rainfall events in Khosroshirin watershed

Table 3: sediment and erosion values by MPSIAC model

Working unit	**specific sediment** *ton/ha/year*	**Erosion** *ton/ha/year*
A1KH	*4.95*	*11.87*
A2KH	*5.05*	*12.62*
B0KH	*6.60*	*17.84*
B1KH	*5.51*	*11.24*
B2KH	*4.60*	*11.5*
B3KH	*5.10*	*12.35*
B4KH	*4.18*	*10.21*
B5KH	*4.97*	*12.75*
C0KH	*7.80*	*15.66*
C1KH	*5.72*	*13.95*
C2KH	*6.00*	*14.64*
C3KH	*5.89*	*14.74*
C4KH	*7.52*	*14.74*
C5KH	*10.80*	*30.91*
C6KH	*9.43*	*23.57*
C7KH	*9.88*	*19.39*
C8KH	*9.44*	*18.82*
C9KH	*7.70*	*15.1*
D1KH	*9.60*	*18.82*
D2KH	*6.98*	*13.96*
D3KH	*5.38*	*10.98*
E0KH	*4.76*	*14.44*
E1KH	*8.11*	*18.04*
E2KH	*8.90*	*20.23*
E3KH	*8.32*	*20.3*
average	*5.77*	*16.47*

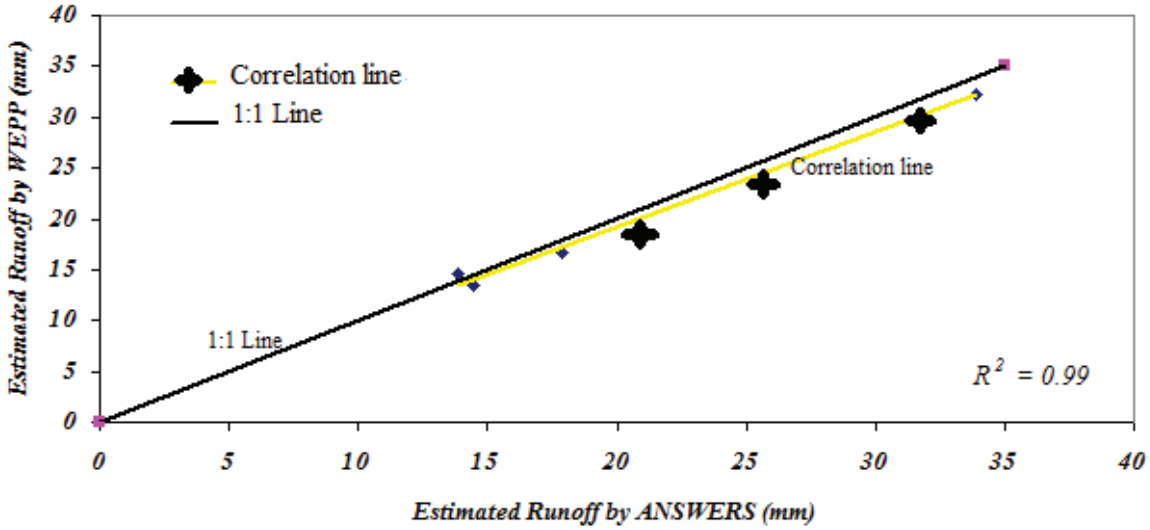

Figure (12): Correlation between estimated runoff by WEPP and ANSWERS models in Khosroshirin watershed and 1:1 fitted line.

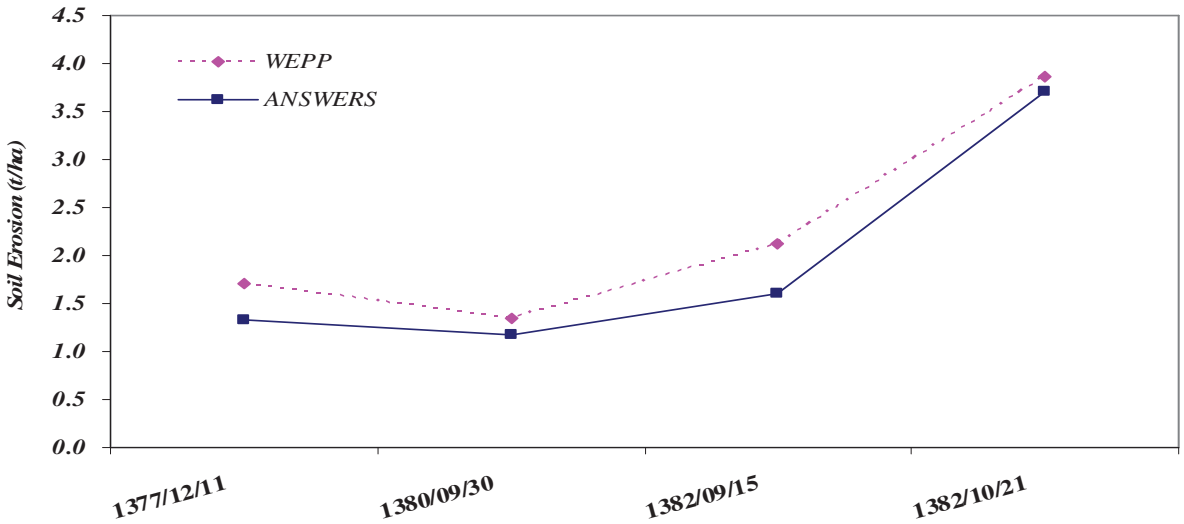

Figure (13): Relationship between estimated erosion by WEPP and ANSWERS models for different rainfall events in Khosroshirin watershed

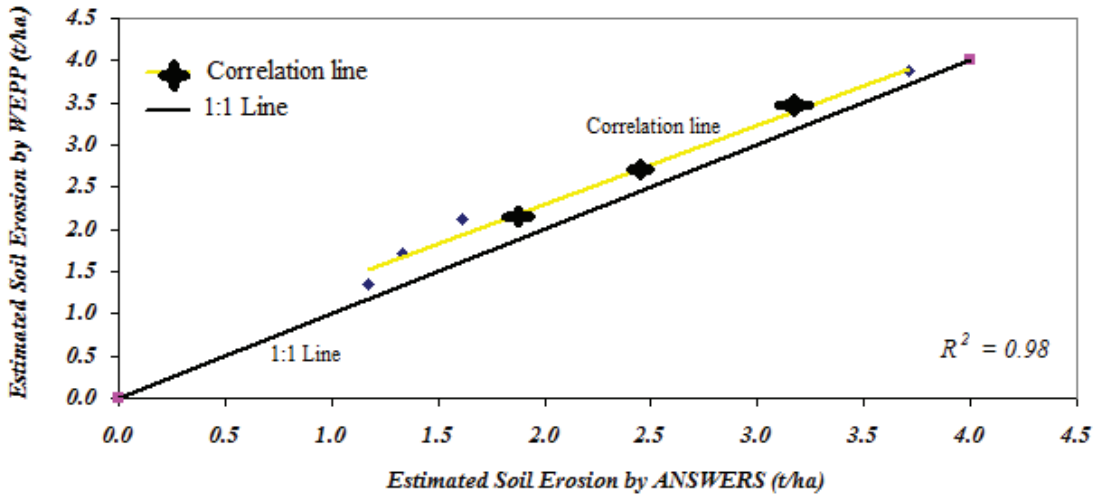

Figure (14): Correlation between estimated runoff by WEPP and ANSWERS models in Khosroshirin watershed and 1:1 fitted line.

Comparing results of MASIAC and WEPP models for Khosroshirin area

The results of runoff values by ANSWERS and WEPP models are fitted well with each other and value of R^2 is more than 0.9 .Also, runoff and erosion values showed similar results (table 2).WEPP and ANSWERS models were compared with F-TEST so there is no significant difference between them. Therefore WEPP model could be used in all different regions.

Regarding to WEPP estimations in B5KH region, sediment values were decreased 16 and 10 times respectively with conservational managements, also data of MPSIAC model are presented (table 3-4).

Conclusion

Results of MPSIAC empirical model shows, erosion and sediment of khosroshirin watershed are 16.48 and 5.77 (ton / hectare) respectively. According to these results (table 3) erosion in region with high longitude is the most where it is which is susceptible to erosion. However; in southern region with agricultural landuse, due to low slope, sediment process is greater. MPSIAC model encounters to serious challenging. Grasslands have a less soil erosion than agricultural landuse, These are related to high organic matter content and soil permeability. A big difference has been between estimated sediment by MPSIAC model and measured sediment. By gauge (5.77(ton/ha/y) and 9.58(ton/ha/y) respectively). Finally, sediment estimation comparison by MPSIAC model with WEPP and ANSWERES models showed that they are more reliable than MPSIAC model. Results of WEPP and ANSWERS models showed that such models could be applied in same region of Iran. MPSIC model is used in Iran but have some disadvantages. Momtahen et al used ANSWERS model to estimate runoff, erosion and sediment in some area with different climate, management ,and physical and chemical soil properties. Results of their studies are similar and showed the good estimations in north are consistent. (Momtahan, 1989). On the other hand, it should be noted that WEPP and ANSWERS model sediment and erosion estimation are for single rainfall event, but MPSIAC model is annually, so we cannot use MPSIAC model estimation planning for single event. Advantages of WEPP and ANSWERS model leads to optimize events and simulate situation.

Table 4: sediment and erosion values WEPP model for annual rainfall

catchment name	specific sediment	Erosion
	ton/ha/year	*ton/ha/year*
A1KH	*7.90*	*17.76*
A2KH	*8.12*	*19.98*
B0KH	*10.70*	*25.72*
B1KH	*9.65*	*16.23*
B2KH	*8.90*	*18.65*
B3KH	*10.65*	*19.23*
B4KH	*12.34*	*26.13*
B5KH	*14.67*	*28.34*
C0KH	*7.87*	*19.67*
C1KH	*11.60*	*18.35*
C2KH	*9.86*	*21.44*
C3KH	*7.89*	*19.53*
C4KH	*15.67*	*35.46*
C5KH	*8.87*	*30.91*
C6KH	*10.43*	*23.57*
C7KH	*9.88*	*22.40*
C8KH	*10.76*	*23.45*
C9KH	*9.76*	*24.51*
D1KH	*12.56*	*21.23*
D2KH	*10.45*	*22.33*
D3KH	*11.76*	*15.88*
E0KH	*12.54*	*19.39*
E1KH	*9.11*	*21.46*
E2KH	*11.65*	*23.45*
E3KH	*8.32*	*25.86*
average	*10.47*	*22.43*

REFERENCE

Bhuyan, S.J., P.K. Kalita., K.A. Janssen and P.L. Barnes. 2002. Soil loss predictions with three erosion simulation models. Environmental Modeling & Software 17 137-146.

Garousi, A, 1997, modification of ANSWERS model to estimate deposition in an agricultural Catchment. MSC thesis, Shiraz University, Faculty of agriculture, Department of water Engineering.

Golkarian. A, 2004, Estimation of water erosion and sediment using WEPP in Ariyeh Niyshabore watershed. Master's thesis. University of Tehran, college of Natural Resources.

Momtahen, h, 1989. Examine ANSWERS model to predict runoff and erosion from a small agricultural catchments, MSc thesis, Faculty of Agriculture, Shiraz.

Nozari, Sh, 2009. Simulating runoff and erosion modeling using ANSWERS model and determination the rate of erosion and sedimentation by MPSIAC model, khosroshirin case study area (Mulla Sadra Dam basin) Fars province. MS Thesis, Shahrekord University, Faculty of Agriculture, Department of Soil Science.

Pandey, A., V. M. Chowdary, B. C. Mal, M. Billib. 2008. Runoff and sediment yield modeling from a small agricultural watershed in India using the *WEPP* model. J. Hydrol. 348: 305-319.

Pieri, L. M. Bittelli, J. Q. Wu, Sh. Dun, D. C. Flanagan, P. R. Pisa, F. Ventura, F. Salvatorelli. 2007. Using the Water Erosion Prediction Project (*WEPP*) model to simulate field-observed runoff and erosion in the Apennines mountain range, Italy. J. Hydrol. 336: 84-97.

Pudasaini, M., S. Shrestha and S. Riley. 2004. Application of Water Erosion Prediction Project (*WEPP*) to estimate soil erosion from single storm rainfall events from construction sites. 3rd Australian New Zealand Soil Conf. 5-9 Dec. 2004. Unive .Sydney, Aust.1-7 pp.

Rajai, sh, 1995. Determination the multiplication factor of clay in sediments derived from the erosion of Catchment in Shiraz University. MSC Thesis, Shiraz University, Faculty of Agriculture, Department of Water Engineering.

Rezaian Zadeh, M, 2009. The KhosroShirin catchment hydrology simulation (Mollasadra dam) using Stanford model (SWM-IV). MSC Thesis, Shiraz University, Faculty of Agriculture, Department of Water Engineering.

Solhi, M, 1988. Study the genetical, morphological, physicochemical, and classification of soils in Badjgah region. MSC Thesis, Shiraz University, Faculty of Agriculture, Department of Soil Science.

Verma, A.K., M.K. Jha and R.K. Mahana. 2010. Evaluation of HEC-HMS and WEPP for simulation watershed runoff using remote sensing and geographical information system. Paddy Water Environ 8:131-144.

Wicshmeier, W. H. and D. D. Smith. 1978. Predicting rainfall erosion Losses. USDA Handbook No. 537. Science and Education Administration. 58p.