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Evaluation of Himeran Reservoir Sedimentation by Using HEC-HMS Software

A Thesis Submitted to the Council of College of Engineering University of Diyala in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering

By

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ABSTRACT

Hemrin dam is an important dam located on the course of the Diyala river. The sediment problem has greatly effect on Hemrin dam and its reservoir. Simulation for sediment entering and deposition in Hemrin reservoir was done using Hydraulic Engineering Center-Hydrologic Modeling System (HEC-HMS 4.1 software). Several input data were used for simulation such as precipitation data for the basin , watershed characteristic, geometric boundary for Diyala river and Hemrin reservoir and water release from Hemrin reservoir. The calibration processes for the model was done by using field measurement data for water discharge from Diyala river and good agreement was reached. The adopted period for simulation was 34 years started from 1981 up to 2014 and the result obtained show that the average annual sediment discharge load to Hemrin reservoir is($3.43x10^6$ ton) while the average annual sediment deposited is ($3.25x10^6$ ton) , the results show that the peak sediment discharge load occurred in November 1984.The simulation suggest that about 49.5% of mass of sediment deposited as clay while the all sediment load out from reservoir as clay. While the silt formed 40.3% of mass of sediment deposited while the sand and gravel are 8.9% and 1.3% respectively. The results prove that there is a strong link between precipitation depth in the basin and sediment entering to Hemrin reservoir. The sensitivity analysis was done by using cover factor and soil erodibility factor for sub basins in the watershed and this processes show that these two factor have large effect on sediment entering and deposition in Hemrin reservoir.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

List of symbols

Symbol	Definition	Dimension
A	watershed area	L^2
A_o	the area of reservoir	L^2
A_s	Surface area of reservoir	L^2
B	top width of the water surface	L
B_J	percentage of active layer composed of material grain class(j)	-
C_e	entrainment coefficient	-
C_f	cover and management factor	-
c	wave celerity	LT^{-1}
D	depth of water	L
d	particle diameter	L
d_{50}	particle size of which 50% is smaller	L
g_s	unit sediment transport capacity	MT^{-1}
H	the reservoir depth at the dam	L
h_o	depth to which the reservoir is completely filled with sediment	L
I_{avg}	average inflow during time interval	L^3T^{-1}
K	soil erodibility factor	-
L	length of control volume	L
LS	the topographic factor	-
M	channel width	L
n	number of grain classes	-
O_{avg}	average outflow during time interval	L^3T^{-1}
P	the support practice factor	-
Q	in or out flow rate from reservoir	L^3T^{-1}
Q_r	surface runoff volume	L^3
Q_s	transported sediment load	MT^{-1}
q	water flow rate	L^2T^{-1}
q_{cr}	critical water flow rate	L^2T^{-1}
q_s	is bed load transport rate	L^2T^{-1}
q_{peak}	the peak runoff rate	L^2T^{-1}
S_o	Channel bed slope	-

s	specific gravity	-
s_d	sediment deposited in reservoir	M
s_i	sediment inflow into the reservoir	MT^{-1}
s_{sus}	suspended sediment in reservoir	MT^{-1}
s_{out}	sediment out from reservoir	MT^{-1}
TE	Trap efficiency	-
T_C	total transport capacity	MT^{-1}
T_P	the time of peak	T
T_J	the transport potential for each material grain class	MT^{-1}
t_{lag}	the basin lag	T
U_p	the unit hydrograph peak	L^2T^{-1}
V	average channel velocity	LT^{-1}
V_o	the sediment volume below new zero elevation of the dam	L^3
V_s	the sediment volume	L^3
V_w	water volume in reservoir	L^3
Δt	the excess precipitation duration	T
ΔS	storage change	L^3
ω	particle fall velocity	LT^{-1}
ν	kinematic viscosity	L^2T^{-1}
μ	hydraulic diffusivity	L^2T^{-1}
γ	unit weight of water	$ML^{-2}T^{-2}$
γ_s	unit weight of solid particles	$ML^{-2}T^{-2}$
τ_o	bed level shear stress	$ML^{-1}T^{-2}$
ŋ	channel elevation	L
λ_p	active layer porosity	ML^{-3}

CHAPTER ONE

INTRODUCTION

1.1 General

The sedimentation is result of erosion which occurs in watershed , transported by with flow and deposited in the reservoir. Soil erosion outlined as the detachment of soil particles from soil mass . This procedure occurs because of some outside effect equivalent to wind , gravity and rainfall . The volume of soil eroded from the watershed depends on many factors that can summarized as fallow the characteristic of rainfall including amount and intensity, the type of soil in watershed ,land cover and topography , the size of soil particles and drainage networks characteristic such as size slop and shape (Yang, 2006). The transport of sediment means the movement of sediment particles. The basic mechanism responsible for the movement of particle is drag force exerted by water flow on individual grains (Henderson, 1966) . The sediment particles usually have three modes of motion(rolling , saltating and suspended), the transport of particles by saltating and rolling is called bed load transport , while the suspended particles are transported as suspended load transport (Van Rijin,1993). Deposition is the final stage of sedimentation process. When the river inter the reservoir the velocity of flow begins gradually to decrease and the solid particles will deposits . The volume of sediment that deposited in the reservoir depends on reservoirs trap efficiency which depends on particle size of sediment , the shape and size of reservoir and operation plan (Yang, 2006).

1.2 Sedimentation in Reservoirs

Sediment transport within the rivers and its accumulation in reservoirs has grown to be an essential challenge that as a rule must be considered. When water flows into the dam reservoir, it carries some amounts of sediments embedded within turbid inflow into the reservoir. These sediments will deposit along the bed of the dam reservoir as the water velocity is reduced. The longitudinal accumulation of sediments in a reservoir may be separated into three main zones depending on sediment characteristics, namely the zone of coarse sediments, delta, and fine sediments. As is conceptually illustrated in the Figure (1.1).

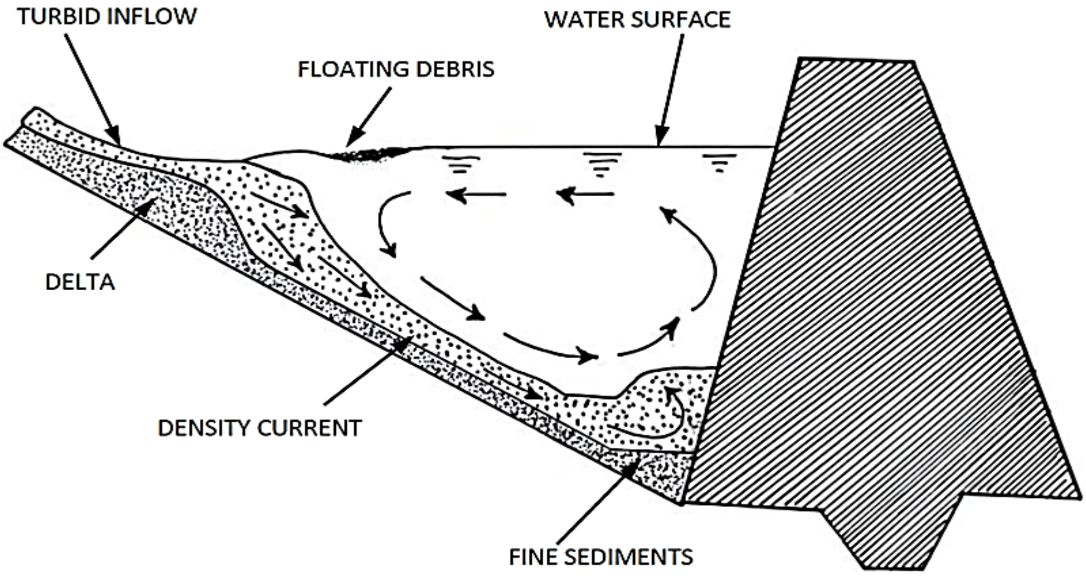


Figure (1.1) Longitudinal profile of reservoir bed (After Morris and Fan 2010)

The longitudinal deposition along the bed profile and the settling patterns differ from one reservoir to another, as is affected by many factors such as geometrical shape of the reservoir, discharge conditions, flood events, size of sediment particles of the inflowing load, and operating conditions of the reservoir(Morris and Fan ,2010).

1.3 Statement of problem

Sediment is the principle problem which affects the useful life of reservoir , causing several problem such as reducing the storage capacity of reservoir, The sediment may deposit near the intake of hydro power and thus cause harm to hydropower system . The sediment accumulation will rise the bed elevation of reservoir and therefore loss flood control .

1.4 Objective

Evaluation of sedimentation in Himeran reservoir by simulating the sedimentation processes using HEC-HMS 4.1 software.

1.5 Methodology

• Collection of data from the study area

• Use HEC-HMS as model

• Model calibration and sensitivity analysis

1.6 HEC – HMS

HEC- HMS 4.1 is a computer program designed by US Army Corps of Engineers, the user for this program become able to do a simulation for precipitation – runoff process . One of the options in this model is sediment transport simulation which enable the user from routing the sediment in each element in the watershed including that the deposition in the reservoir(HEC-HMS user manual,2015).

1.7 Thesis Layout

Chapter one :- contain an introduction about reservoir sedimentation, the objective and methodology of the study and simple description for HEC-HMS 4.1 software.

Chapter two:- is a literature review of investigation related to subject, important research focused on reservoir sedimentation and methods used for predicting reservoir sedimentation.

Chapter three:- contain the theory, equation, assumptions and limitation used by the Hydrologic Engineering Center (HEC) for designing HEC-HMS 4.1 software.

Chapter four:- is a description of the Diyala river basin and Himeran reservoir Which were used as case study.

Chapter five:- show the model calibration, result obtained from simulation for sedimentation in Himeran reservoir and sensitivity analysis.

Chapter six:- explain the conclusions that are reaches at from this study and some recommendations for future research work.

CHAPTER TWO

BASIC CONCEPTAND LITERATURE REVIEW

2.1 Introduction

Reservoir sedimentation has been the main problem which affected on reservoir efficiency . In the early history of development of reservoir a little attention was given to sedimentation factor in design, this was causing problem to many dams over the world for example Taiwan's shihmen Reservoir lost 45 percent of its capacity in period 1963-1968, Mandali small dam in Iraq with total storage of 6400000 m^3 this project fail due to accumulation of sediment in the upstream of dam. Attention is thus paid by the researchers to the importance of reservoir sedimentation problem which has been traded a like in series of studies.

2.2 Trap efficiency

Trap efficiency can be defined as the ratio of sediment deposited in the reservoir to the amount of sediment entering the reservoir. The trap efficiency is mostly used in empirical method to calculate the reservoir sedimentation , the method which use trap efficiency is very simple to estimate the sediment load deposited in the reservoir. This some of study focused on trap efficiency.

Brown(1943) used actual data from 34 reservoir to develop the Figure (2.1) for calculating the trap efficiency of reservoir.

Brune (1953) presented an empirical relationship between the trap efficiency and ratio between reservoir capacity – water inflow based on observation of 44 reservoir , from the relationship he made a curve show in Figure (2.2).

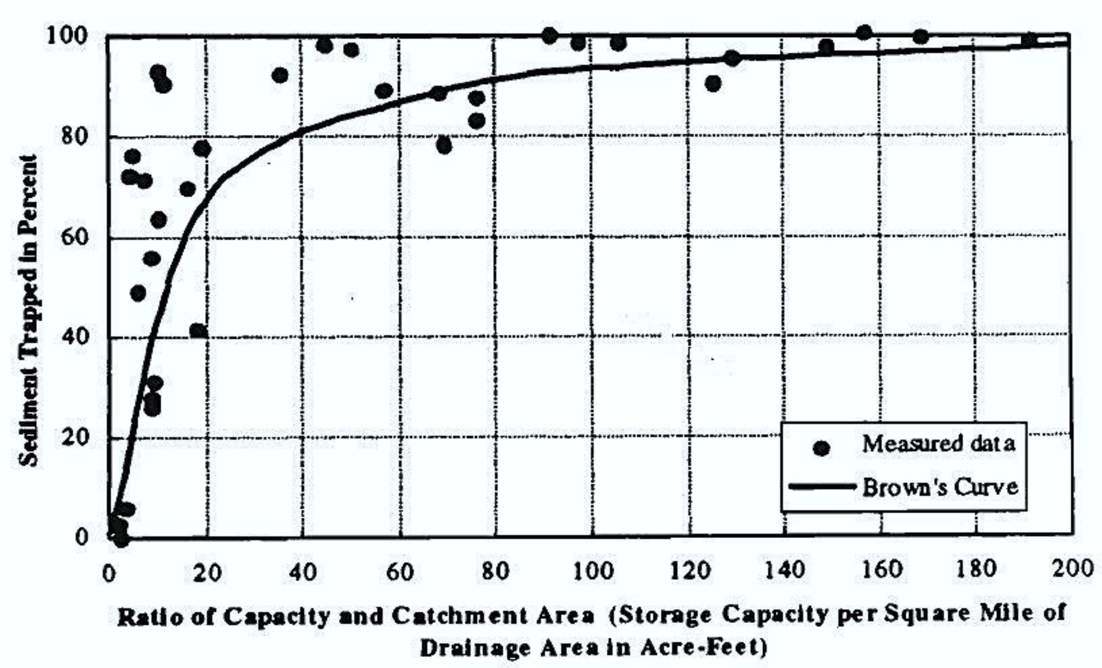


Figure (2.1) Reservoir trap efficiency (after Brown 1944)

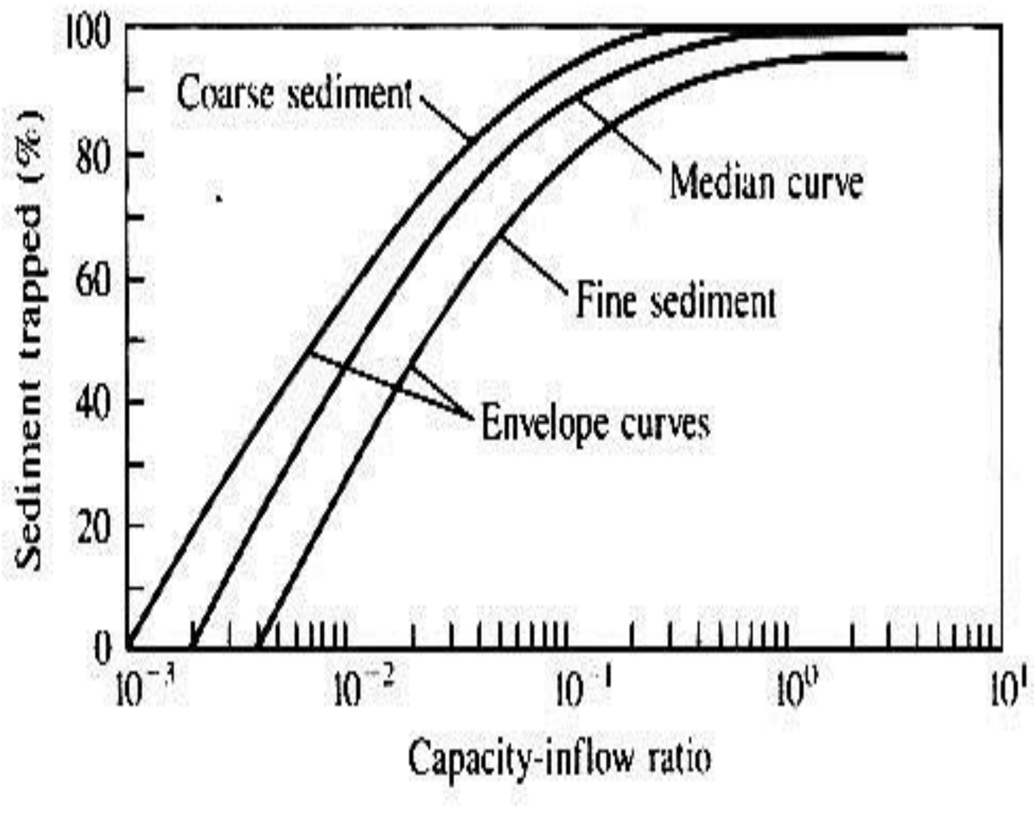


Figure (2.2) Trap efficiency of reservoir (after Brune 1953)

2.3 Prediction methods of reservoir sedimentation

Great effort have been made by the researchers to describe the process of sedimentation in reservoir. At first most studies were toward of empirical and were based on a few observation, mathematical model has been used then to describe the phenomenon. Two types are realized empirical methods and mathematical models.

2.3.1 Empirical methods

These methods mainly depend on observation of sediment in actual reservoir. These methods are characterized by their limited to a few features, and don't include all side and condition of reservoir sedimentation and it have simplicity and the data requirement are less,(Ghomeshi ,1995). Be mentioned.

Cristofano (1953) presented (Area – increment) for predicting sediment distribution in the reservoir. In this method the assumes that the deposited sediment reduces the area of the reservoir with fixed amount. The basic equation used in this method is as follows:

$$V_s = A_o(H - h_o) + V_o \qquad \text{.....................................(2-1)}$$

Where:

V_s : is the sediment volume (m^3)

A_o : is the area of reservoir (m^2)

V_o : is the sediment volume below new zero elevation of the dam (m^3)

H : is the reservoir depth at the dam (m)

h_o: is the depth (m) to which the reservoir is completely filled with sediment.

Borland (1971) developed a method for predicting the slopes of sediment that deposited in delta formation. This method is based on observation data for 30 reservoir in USA , Borland makes a graph between the topset slopes and river slop. As shown in Figure (2.3).

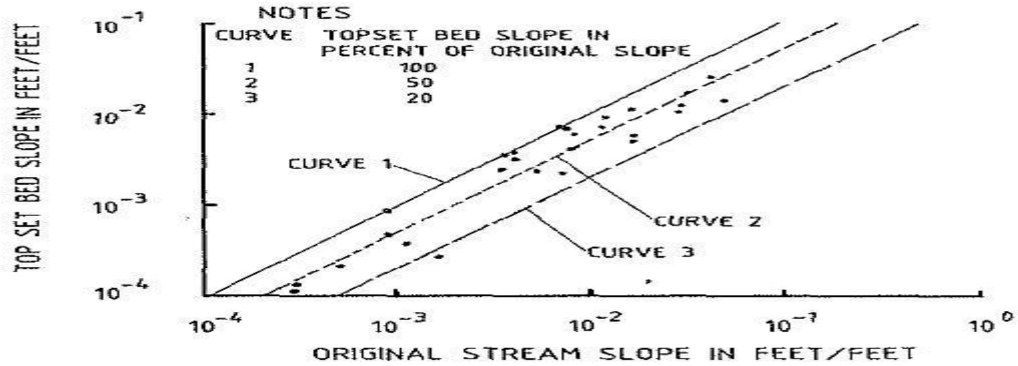


Figure (2.3) Borland's ratio curve (after Borland, 1971)

2.3.2 Mathematical models for sedimentation

Mathematical model has been based on solution of all phenomena which affecting on sedimentation in reservoir . Mathematical model usually need the computer to helping it in the calculation . a number of mathematical study for reservoir sedimentation are briefly mentioned as follow:

Yucel and Graf (1973) developed a mathematical model to predict the amount and pattern of bed load deposition in a reservoir . The calculation was made with input of three different sediment size . The main objective from the model was to predict the deposition . The analysis was made in two stage the back water profile and the sediment transport and deposition these two stage are made independently . The back water calculation in this model was developed by stander step method and the bed load calculation used the same section that used in the back water calculation .In this study used the scotklitch equation(equation 2-2) , the meyer-peter et al and Einsten -1942 bed load equation to calculate the bed load deposition , then made a Comparison between the result obtained from the three different equations, as shown in Figure(2.4).

$$q_s = N\, S_o^z (q - q_{cr}) \quad \ldots\ldots(2\text{-}2)$$

q_s : is bed load transport rate in volume per unit time per unit width

S_o : channel bed slope

q : water flow rate in volume per unit time per unit width

q_{cr} : critical water flow rate at which the bed material begins to move

N, z : empirical sediment coefficients

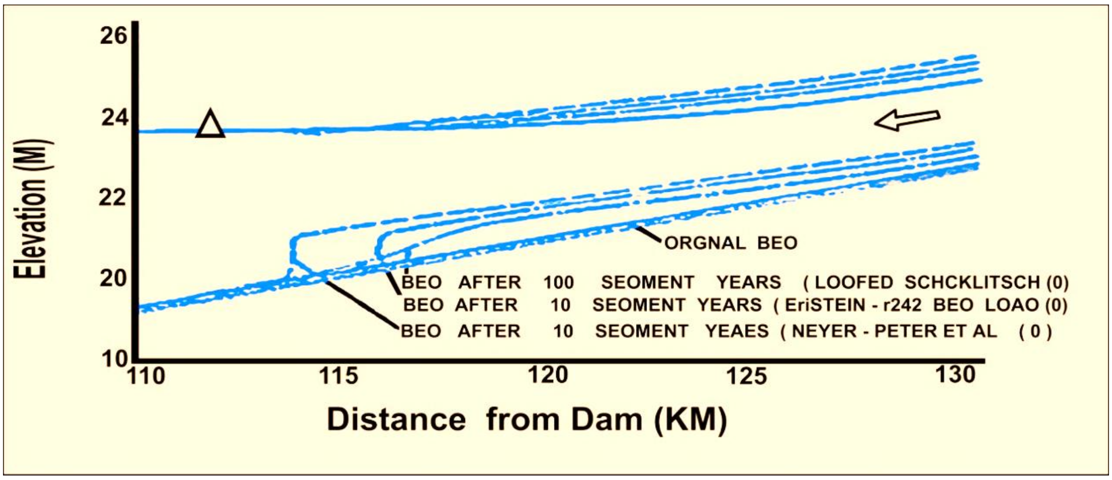


Figure (2.4) Comparison of the total bed load deposition rate obtained with the three different bed load equations for hypothetical reservoir (after Yucel and Graf 1973).

Finally the authors concluded that the delta formation that appear in the upstream of the reservoir formed as a result of accumulated of sediment , the meyer-peter et al and the Einsten -1942 bed load equation predict bed load a rate faster than schokitch equation .

Lopez. et.al (1978) developed a mathematical model to predict the volume and pattern of the sediment deposition in river reservoir system. The model deals with the reservoir as a set of multiple channels and uses a compound stream model approach with jet theory to route the water and sediment flow. Lopez divide the entire river reservoir system into three parts. The river is the part located at upstream mouth of reservoir, the transition zone is the connecting of the river to reservoir while the reservoir is located from transition zone down to the dam, as it is shown in the Figure(2.5).

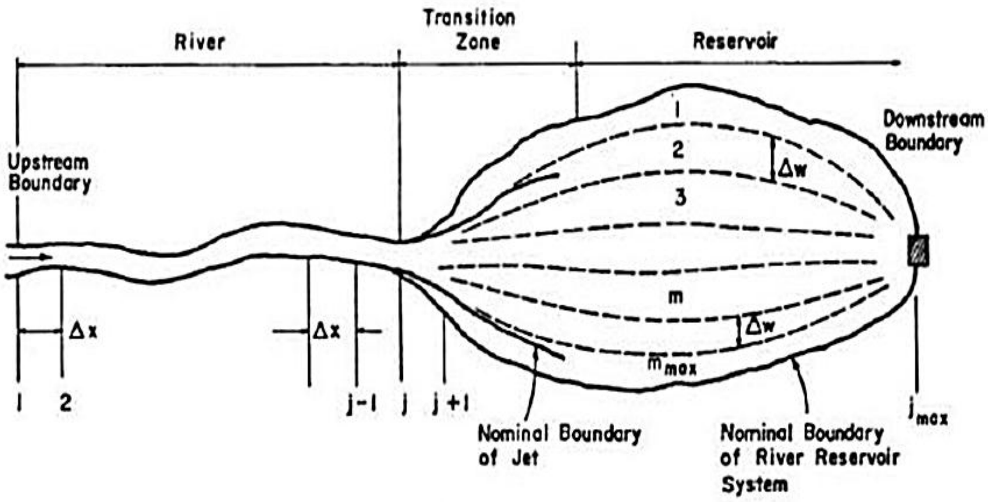


Figure (2.5) Schematic of the river - reservoir system (after Lopez et.al 1978)

The mathematical analysis of the change in river bed are generally depends on motion and continuity equation. The model that developed in this research can be applied to water and sediment routing in subcritical flow, the verification in this study done by two ways the first way the sediment pattern in sudden expansion is study by a physical model built in a laboratory and the second way by the available data from the lower Colorado river. The result from this two way compare with the result obtain from a mathematical model and it found that there is a significant mismatch between the two results.

Soares , et al. (1982) present a study to discuss the development of stochastic and deterministic model to predict the sediment deposition in the reservoir as a function of time in year, the study falls into three paper. The first paper discusses development of a stochastic model and the second paper deals with development of deterministic model while the third paper contain the compression between the result obtained from the two models and the measured data for the Johan Martin reservoir ,Colorado. The stochastic model is presented as additive process defined on a finite Markov chain and the model is based on Morans dame storage, in the deterministic model they need to use some assumptions such as the pressure distribution in vertical hydrostatic, the sediment – water mixture is homogenous and there is no loss due to seepage and evaporation, the governing equation in this model is solved by implicit finite difference scheme and treated with inflow into reservoir as unsteady and none uniform . The deterministic model used to determine the distribution of sediment along the length of reservoir. The compression in third paper prove that the model has a good agreement with measured data.

Ghomeshi (1995) developed a computer program (DEPO) by Fortran 77 to predict sedimentation in reservoir. The model was one – dimensional and it was verified by the use of the laboratory flume. The proposed model (DEPO) was applied on Dez Reservoir, Iran, to predict the sediment volume and bed elevation of reservoir. The result showed that the model had a good ability to predict sedimentation in reservoir.

Mirza (1995) developed a mathematical model to simulate and evaluate the amount of sediment trapped in Himeran reservoir. He write a computer program by Fortran77 the program was contain a several subroutine to compute water inflow and sediment inflow to the reservoir. The result obtained from the model include the volume of sediment trapped in hemrin reservoir , the sediment distribution , the reservoir pool elevation and zero elevation . The compression made between the result obtain from model and the actual value for ten year simulation period a reasonable agreement was observed between the actual data and result obtained from the model.

Saenyi and Holzmann (2002) used the water erosion prediction project (WEEP) model to masinga catchment area in Kenya for estimation the amount of soil eroded by the runoff resulting from rainfall, and then they use GSTAR 2.1 model to make a simulation to reservoir sedimentation processes . They found out that two computer model able to simulate and predict sediment transportation and deposition in reservoir.

Tan (2005) applied a mathematical model to study sedimentation in three gorges project . He use artificial neural network of runoff yield and soil erosion to estimate the sediment yield in the river and use three 1-D mathematical model (HELIU-2 developed by YRSRI, MI-NENUS-3 developed by IWHR , QHXXSI developed by TU) in predicting the amount of sediment entering to three gorges project . The researcher used the field data to made a verification to 1-D mathematical model (HELUI-2 and MI-NENUS-3). The verification of mathematical model showed that the result had been affordable agreement with measured data and the compression between result found by model and field data of reservoir in three gorges project it was found the validity of conclusion depended on several factors such as model accuracy, correctness of boundary condition and reliability of data .

Khawaja and Sanches (2009) taken in account different morphological parameter to predict evaluation of sediment deposited in reservoir . This process was made using RESSASS (1-D model made by Tams & HR Wallingford,1998) model to calculate the concentration at the downstream of each section . Then the researcher made a compression between the actual data and the result obtained from model , they found out that two results were identical.

Pak et.al. (2010) present the comparison between the result gated by HEC-HMS model and observation data of flow and sediment for two reservoir in upper north of Bosque river watershed in central of Texas and then the result show that the HEC-HMS model had a reasonable prediction of sediment accumulation in the bottom of reservoir.

Beebo and Raja (2012) used HEC-RAS to simulate the change in a bathymetric in up stream of sikuma dam ,japan . After they made the calibration and sensitivity analysis of the model they found the amount of sediment deposited in the upstream of dam and loss in storage capacity of the reservoir and they made the prediction to the future by assuming that the existing flow data could be recycled and estimated the useful life of reservoir.

Tiwari and Sharma (2012) made a simulation and predicting to sedimentation processes in Wangchu (Bhutan) reservoir by using HEC-RAS model , they made the simulation with the help of fourteen year of sediment discharge data , the researchers predict the change in elevation of reservoir due to sediment deposition .

Moussa (2013) used a two dimensional numerical model (CCHE-2D) to simulate and predict the water level and sediment deposited in Aswan High Dam Reservoir (ASHDR) . The study Area was selected between 500 km and 350 km upstream the Aswan Dam with total length 150 km, the model (CCHE-2D) made the mesh to the reservoir to use it in the simulation process. The calibration and validation for the model was done in this study by data was collected from study Area at the year 2006 – 2007 and found a reasonable agreement, the model was used to predict the elevation of sediment at different cross sections of reservoir and found that a good agreement between the model and observation. Finally the calibrated model was used to predict the water level and longitudinal bed elevation for the reservoir at the year between 2009 – 2014.

Hobi (2014) selected Haditha reservoir as a case study used in numerical model , it represent a substantial grosses from reservoir storage . The model was simulated delta formation , the simulation for reservoir sedimentation was done by using numerical model and SSIIM software packedge which is power full software used for prediction and simulation of metrological change in reservoir . The researcher solved Navier stokes equation for turbulence flow to obtain the velocity of water and used k-ϵ model for calculating turbulence shear stress. He used the available topographic map of Haditha and by using 3D-MAX software made the grid to reservoir before starting storing which is need to use in main model to calculate sediment in the reservoir . The researcher make a sampling to bed sediment material in reservoir to find the specific gravity that use as initial value in the model and calculate the sediment discharge at five cross section of reservoir by running the model the model was run to simulate one year morphological changes in reservoir considering the discharge which carries most of sediment into the reservoir. The result show that the most sediment deposited at the beginning of reservoir at delta region which cause change in the bed level of reservoir. The result also prove that the fluctuation of water level in the model has direct influence on the shape and location of deposition as well as on the depth of accumulation sediment in the delta.

Patil and Shetar (2016) exploited Artificial Neural Network (ANN) to predict the sediment deposited in Shiraji Sagar reservoir on the Koyna river in India. ANN a potent technique to develop the relationship between the input and output such as inflow, rainfall, sediment deposition and capacity of reservoir. The researcher’s developed an ANN model for estimating the sediment deposition in reservoir. The input parameter selection has been according to the influence of parameter on the sedimentation process, the model was typical ANN model containing three layer (input , output and hidden layer where the process done). The observation data for study Area for fifty three year use to calibration of the model. Finally they found that ANN model have a good accuracy in the estimation of sedimentation of reservoir and it required less effort as compared to conventional regression analysis.

Ezz-Aldeen et.al. (2016) used soil water assessment tool (SWAT) and water erosion prediction project (WEEP) models to predict runoff and sediment load for Dhouk Dam Reservoir for period 1988 – 2011. They made the calibration to the two models to ensure the model ability this process was done with the aid of available data from study area for period 2008-2009. The result obtained from the two model gave a good agreement with measured data. Finally based on the result obtained from the models they presented a relationship between run off – rainfall, sediment – rainfall and sediment – runoff

2.3.3 Physical surveying

In addition to empirical methods and mathematical models there other method are used to determine reservoir sedimentation such as physical surveying , as an example .

Al-Ansari (1987) made bathymetric survey for Himeran reservoir . The survey was carried out during the second half of 1985 where the water level was about 96 m (above sea level), some equipment was used in the bathymetric survey in Himeran reservoir such as Hewlett Packard 9826 computer which use to record data, Hewlett Packard 2671 G printer this device is used to give hard copy print out of any data file required for manual interpretation and some other equipment and software. From this survey it was found that the longest axis of Himeran reservoir reaches 36.5 km at maximum impounding level (107.5) and the maximum width is 12 km near the entrance of Diyala river to reservoir, and found the slopes of reservoir bed at different location, and also take 130 samples from reservoir bed obtained it by van veen grab, the samples collected for three different water level for reservoir (87,95,101) and then the researcher determined the percentage of sand, silt and clay for sediment bed at each water elevation, and for suspended sediment also collected surface water sample at different water level (87,95,101), and find the concentration of suspended sediment which determined by filtered 1 liter of water and filtered it by membranes of 0.45 micron average diameter. The author observed a different in the concentration of suspended sediment from one position to another at the same water elevation, he attributed this to the special shape of Himeran reservoir.

2.4 Summary

Through literature review of reservoir sedimentation was found that this studies not fully covered Himeran reservoir sedimentation for example Mirza study was For only ten years after the construction of the dam so this study was carried out. The previous study contributed in one way or another in this study for example the study presented by Pak et.al. reinforce confidence in the model used in this study, the research of AL-Ansari describe the study area including Himeran reservoir. While the other studies contributed to give a clear and detailed conception of history and evolution the models which deals with reservoir sedimentation science the establishment of interest in the subject to the time of study.

CHAPTER THREE

THEORTICAL ANALYSIS AND MOEDL DEVELOPMENT

3.1 Introduction

Basically most of mathematical model is based on a set of theories and equations with both boundary condition and initial condition concerned with the objective that the model is designed to it so in this chapter we will review the equation that used by the Hydrologic Engineering Center (HEC) for designing the model (HEC-HMS 4.1).Figure (3.1) show the flow chart Summarizes the simulation.

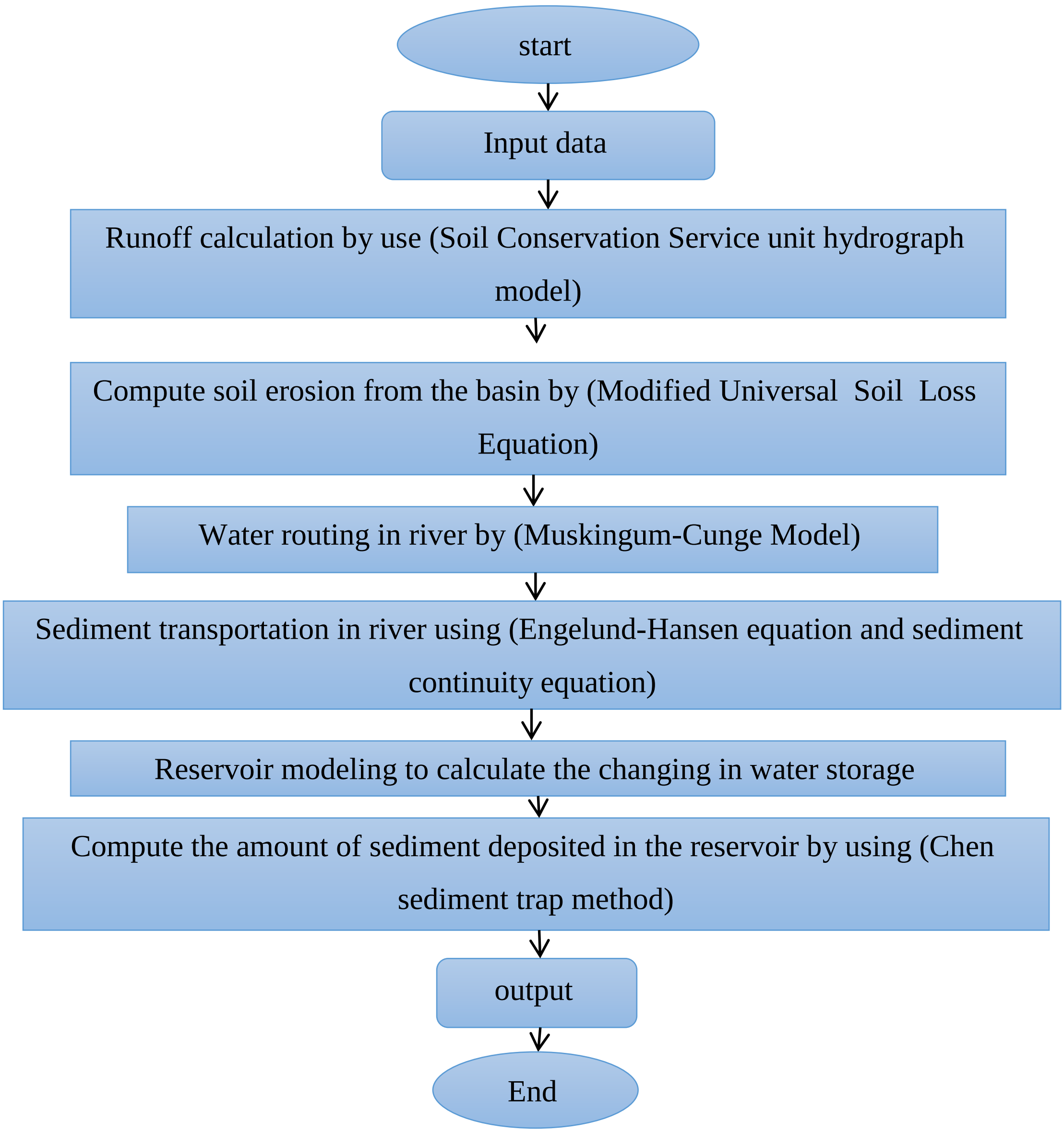


Figure (3.1) Simulation flow chart

3.2 Soil Conservation Service Unit Hydrograph Model

The soil conservation service (SCS) suggested a parameter UH model , HEC-HMS depend on this model to predict runoff volume . The model is based on averages of UH obtained from gage rainfall and runoff from a large number of small agricultural watersheds throughout the us SCS technical report 55 and the national engineering handbook (1971) described the UH in detail.(HEC-HMS technical reference manual, 2000)

3.2.1 Basic Concept and Equation

At heart of ScS UH model is a dimensionless , single – peaked UH it is dimension less UH , Which will be show in Figure(3.1) , expressing the UH discharge U_t as a ratio to the UH peak discharge for any time t , a fraction of Tp , the time to UH peak . research by ScS suggest that the UH peak and time of peak are related by :

$$U_p = c\ \frac{A}{T_P} \qquad \text{(3-1)}$$

In which U_p is the UH peak, A is watershed area and C is conservation constant (2.08 in SI and 484 in foot pound system) the time of peak is related to the duration of the unit excess precipitation as :

$$T_P = \frac{\Delta t}{2} + t_{lag} \qquad \text{(3-2)}$$

In which

Δt = the excess precipitation duration

t_{lag} = the basin lag

When the lag time is specified , HEC – HMS solved equation (3-2) to find the time of UH peak and equation(3-1) to find the UH peak , with U_p and T_P known the UH can be found from dimensionless form which included in HEC – HMS .(HEC-HMS technical reference manual,2000)

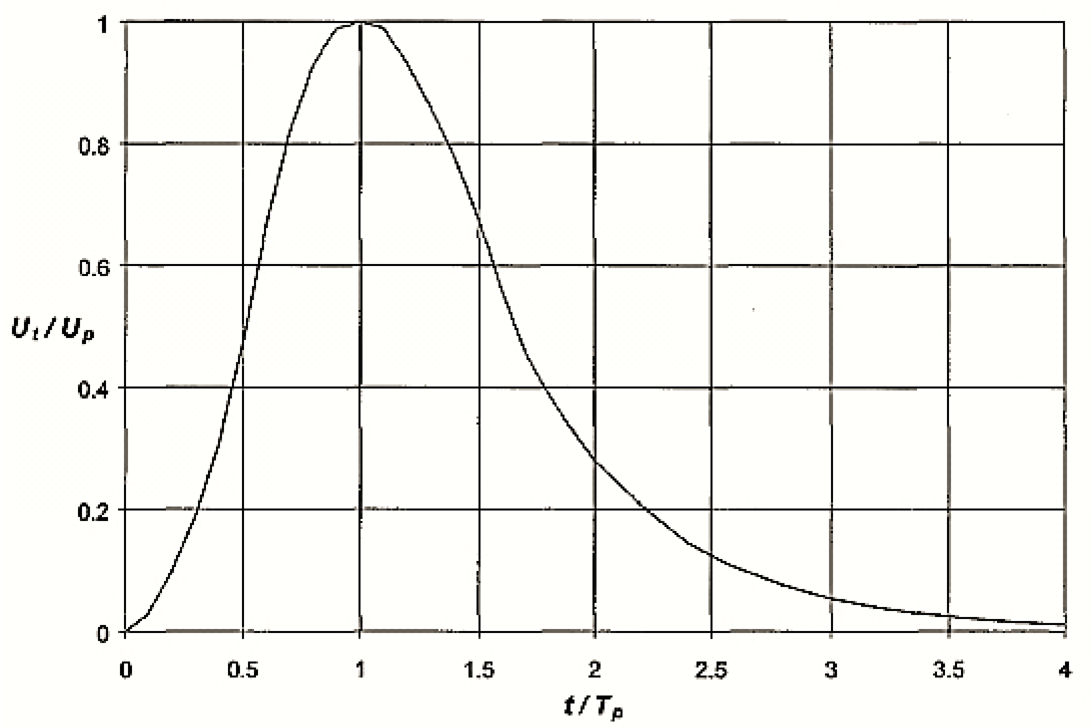


Figure (3.2) SCS unite hydrograph

3.3 Erosion Methods

A sub basin element symbolize a watershed where the runoff occurs due to Rainfall. Rain drop causes erosion when they hit the surface of the ground and break apart the top layer of soil, dislodging soil particles to move with the overland flow . Overland flow also causes an erosive energy to the ground surface which lead to break apart the top soil layer . As the overland flow rate increases lead to increasing erosive energy and further erodes the surface . Most of soil eroded from the catchment may be not reached to the outlet of sub basin and deposited within the catchment. HEC – HMS use Modified Universal Soil Loss Equation (MUSLE) to calculate the sediment yield from sub basin for a storm event.(HEC-HMS user manual, 2015)

$$Sed = 11.8(Q_r \cdot q_{peak})^{0.56} \cdot K \cdot LS \cdot C_f \cdot P \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3\text{-}3)$$

Where

Sed = the sediment yield for a given event (tons)

Q_r = the surface runoff volume (m^3)

q_{peak}= the peak runoff rate (m^3/s)

K = the soil erodibility factor, describes the difficulty of soil erosion. This factor is based on soil structure, texture and organic matter content.

LS = the topographic factor

C_f = the cover and management factor the typical value for this factor ranges between 1 for bare soil to 0.1 for fully covered soil.

P = the support practice factor

3.4 Fall Velocity Method

The suspension of a sediment particle is initiated when the bed-level shear velocity be the same value as the fall velocity of that particle. The sediment particle will be still in suspension as long as the vertical components of the bed – level turbulence is larger than the fall velocity. Therefore, the calculating of suspended sediment transport has a strong link with the particle fall velocity.

Van Rijin 1993 approximated the US inter- agency committee on water resource curve for fall velocity using particles with non- spherical shape having a shape factor of 0.7 in water having temperature of 20 c . Three equation are used particle size as a control parameter .(HEC-RAS hydraulic reference manual,2010)

$$\omega = \frac{(s-1)gd}{18v} \quad 0.001 < d \leq 0.1 \text{ mm}$$

$$\omega = \frac{10v}{d}\left[\left(1+\frac{0.01(s-1gd^3}{v^2}\right)^{0.5} - 1\right] \quad 0.1 < d < 1\text{mm} \qquad \text{………(3- 4)}$$

$$\omega = 1.1\,[(s-1)gd]^{0.5} \qquad d \geq 1\text{mm}$$

Where

ω = particle fall velocity (m/s)

ν = kinematic viscosity (m^2/s)

s = specific gravity

d = particle diameter (mm)

3.5 Muskingum – Cunge Model

This model is used to routing the water at reach element . The model is based upon solution of the following form of the continuity equation , (with lateral inflow , q_l included)

$$q_l = \frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} \qquad \text{...(3-5)}$$

and the diffusion form of the momentum equation

$$s_f = s_o - \frac{\partial y}{\partial x} \qquad \text{...(3-6)}$$

Combining these and using a linear approximation yields the connective diffusion equation (Miller and Cunge l975) :

$$\frac{\partial Q}{\partial t} + c\,\frac{\partial Q}{\partial x} = \mu\,\frac{\partial^2 Q}{\partial x^2} + cq_l \qquad \text{.. (3-7)}$$

Where c = wave celerity and μ = hydraulic diffusivity , the wave celerity and hydraulic diffusivity are expressed as follows :

$$C = \frac{dQ}{dA} \qquad \text{... (3-8)}$$

$$\mu = \frac{Q}{2BS_0} \qquad \text{...(3-9)}$$

B = top width of the water surface

A finite difference approximation the partial derivatives , combined with below equation

$$O_t = \left(\frac{\Delta t-2kx}{2k(1-x)+\Delta t}\right)I_t + \left(\frac{\Delta t+2kx}{2k(1-x)+\Delta t}\right)I_{t-1} + \left(\frac{2k(1-x)-\Delta t}{2k(1-x)+\Delta t}\right)o_{t-1} \text{ ………… } (3\text{-}10)$$

$$O_t = C_1 I_{t-1} + C_2 I_t + C_3 O_{t-1} + C_4(q_l \Delta x) \text{ ……………………….. } (3\text{-}11)$$

The coefficient are

$$\left.\begin{aligned} C_1 &= \frac{\frac{\Delta t}{k}+2x}{\frac{\Delta t}{k}+2(1-x)} \\ C_2 &= \frac{\frac{\Delta t}{k}-2x}{\frac{\Delta t}{k}+2(1-x)} \\ C_3 &= \frac{2(1-x)-\frac{\Delta t}{k}}{\frac{\Delta t}{k}+2(1-x)} \\ C_4 &= \frac{2(\frac{\Delta t}{k})}{\frac{\Delta t}{k}+2(1-X)} \end{aligned}\right\} \text{ …………………….}(3\text{-}12)$$

The parameter k and x are

$$K = \frac{\Delta x}{c} \text{ ……………………………………………..…………}(3\text{-}13)$$

$$X = 0.5\left(1-\frac{Q}{BS_O C\,\Delta X}\right) \text{ …………………………………….……….}(3\text{-}14)$$

But c, Q and B change with time , so the coefficient C_1, C_2, C_3 and C_4 must also change so the model (HEC-HMS) recomputed these case at each time and distance stapes.(HEC-HMS technical reference manual 2000).

3.6 Sediment Transport In Reach

Sediment process within a reach is largely affected by the capacity of reach to carry the sediment load. the transport capacity of stream flow can be founded based on the flow parameter and properties of sediment . if the transport capacity of the stream larger than the sediment contained in the inflow , the flow will cause the erosion for stream bed to make up the difference between the transport capacity of stream and sediment contain in the inflow . However if the flow in the reach cannot transport the sediment of the inflow entrained the sediment will be deposited to reach bed. The capacity of transport sediment is calculating using the transport potential method . (HEC-HMS user manual, 2015)

3.6.1 Sediment Transport Potential Method

Sediment transport potential is the measure of how much material of particular grain class a hydrodynamic condition can transport , the program includes several options of transport equation to compute the transport potential , since most of these equations are developed to be used for single grain size like the d_{50} (or, at the most two grain size like the d_{50} and the d_{90}) the equation is applied independently to each grain class regardless of their prevalence in the bed called the transport potential.

3.6.2 Engelund-Hansen

The Engelund-Hansen function is a total load predictor which gives adequate results for sandy rivers with substantial suspended load. It is based on flume data with sediment sizes between 0.19 and 0.93 mm . It has been extensively tested, and found fairly consistent with field data.

The general transport equation for the Engledund – Hansen function is represented by:

$$g_s = 0.05\,\gamma_s V^2 \sqrt{\frac{d_{50}}{g(\frac{\gamma_s}{\gamma})}}\,\left[\frac{\tau_o}{(\gamma_s-\gamma)d_{50}}\right]^{3/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3\text{-}15)$$

Where:

g_s = unit sediment transport capacity (ton/day)

γ = unit weight of water (N/m^3)

γ_s = unit weight of solid particles (N/m^3)

V = average channel velocity (m/s)

τ_o = bed level shear stress (N/m^2)

d_{50} = particle size of which 50% is smaller

The τ_o is found from equation

$\tau_o = \gamma.\ D.\ So$ ………………………………... ……….. (3-16)

Where

D = depth of water

S_o = channel bed slope

The total transport capacity is

$T_c = \sum_{j=1}^{n} B_J T_J$ ………………………………. …………. (3-17)

T_c = total transport capacity

n= number of grain classes

B_J = percentage of active layer composed of material grain class (j)

T_J = the transport potential for each material grain class

3.6.3 Sediment Continuity

The HEC – HMS sediment routing in reach based on solving the sediment continuity equation.

$(1-\lambda_p)\ M \frac{\partial \eta}{\partial t} = - \frac{\partial Q_S}{\partial X}$ ………… (3-18)

Where:

M = width of channel

ŋ = elevation of channel

λ_p= active layer porosity

t= time

x = longitudinal distance

Q_S= transported sediment load

This equation is simply states the change in the volume of sediment equal to the variance between the inflow and outflow load .

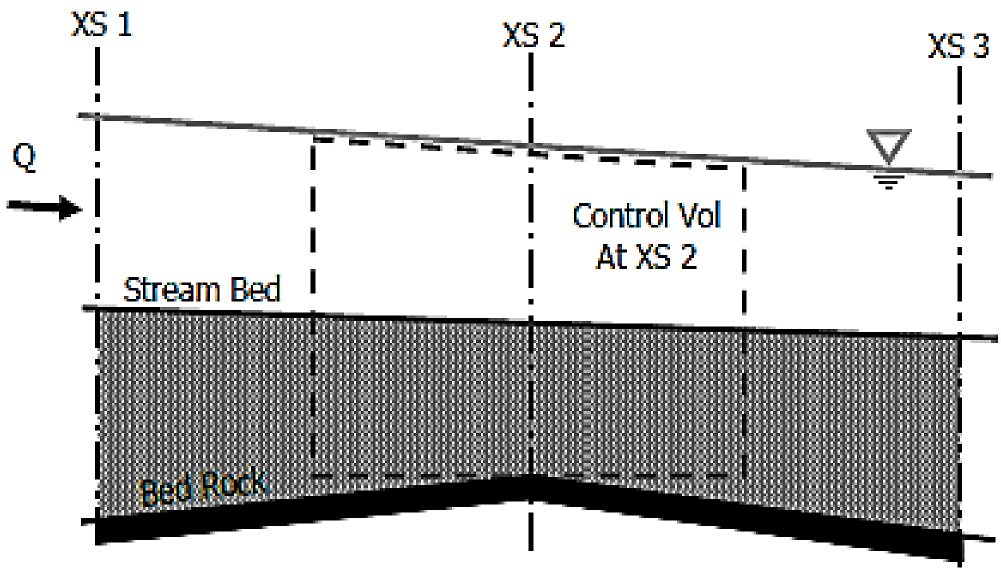


Figure (3.3) Schematic of the control volume used by HEC-HMS for sediment calculation

The sediment continuity equation is solved by computing sediment transport capacity in the control volume for each cross section, then the transport capacity comparing with sediment inflow to the control volume from the upstream ,if the capacity greater than supplied then the erosion in the control volume will take place vice versa if the capacity is lower than supply the deposition will happen, the theory of deposition in reach depend on comparing the vertical distance from particle position to the bed surface and the vertical distance particles travel at a time step (fall velocity * time) .While the erosion process done based on entrainment coefficient:

$$C_e = 1.368 - e^{-(\frac{L}{30.D})} \quad \ldots\ldots (3\text{-}19)$$

Where C_e = entrainment coefficient

D = depth of flow

L = length of control volume

The resulting entrainment coefficient for length to depth ratio between zero to forty are plotted in Figure (3.3).

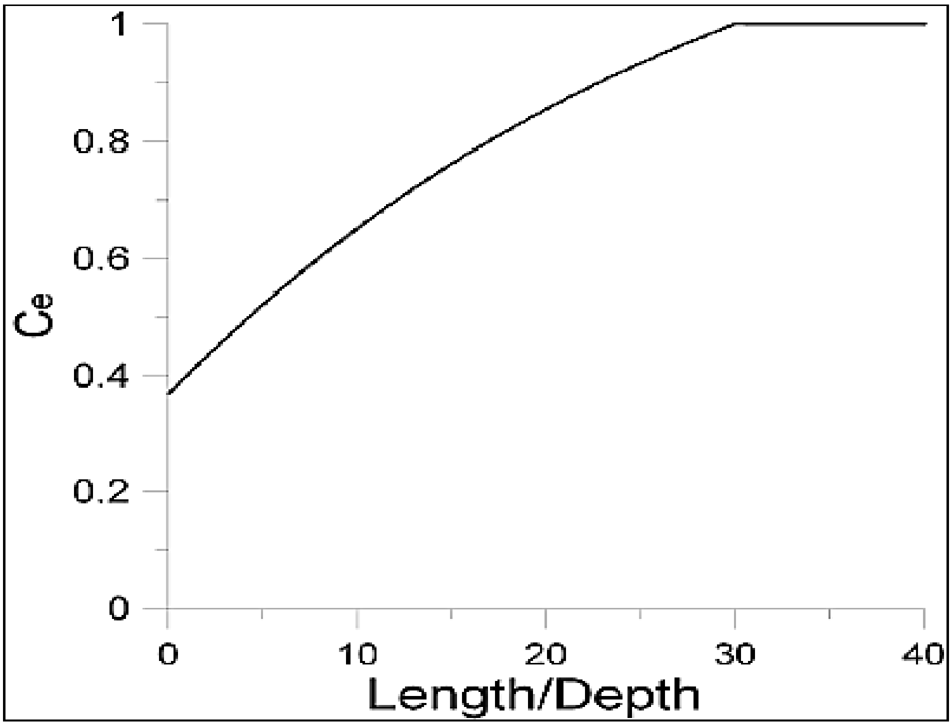


Figure (3.4) The calculated entrainment coefficients for range of control volume length to depth ratio (after HEC- RAS 2010)

If the length to depth ratio exceed 30 the coefficient goes to one and all deficit is eroded from cross section while if C_e equal 0.368 the program will always allow at least 36.8% of deficit to erode.(HEC-RAS hydraulic reference manual 2010) .

3.7 Reservoir Modeling

The model discretizes the total time of analysis into equal intervals of duration Δt . it then solves recursively the following one – dimensional approximation of continuity equation :

$$I_{avg} - O_{avg} = \frac{\Delta S}{\Delta t} \quad \text{…….………………………………. ……. (3-20)}$$

Where

I_{avg} = average inflow during time interval

O_{avg} = average outflow during time interval

ΔS = storage change

With finite difference approximation , this can be written as :

$$\frac{I_t + I_{t+1}}{2} - \frac{O_t + O_{t+1}}{2} = \frac{S_{t+1} - S_t}{\Delta t} \quad \text{……………………………………….(3-21)}$$

In which t = index of time interval

I_t and I_{t+1} = the inflow values at beginning and end of the t^{th} time interval respectively

O_t and O_{t+1}= corresponding the out flow value

S_t and S_{t+1} = corresponding storage values

this equation can be rearranged as follows :

$$\left(\frac{2S_{t+1}}{\Delta t} + O_{t+1}\right) = (I_t + I_{t+1}) + \left(\frac{2S_t}{\Delta t} - O_t\right) \quad \text{………………………… (3-22)}$$

All terms at right side are known , the value of I_t and I_{t+1} are inflow hydrograph ordinates the value of O_t and S_t are known at the t^{th} time interval . at t = 0 these are initial condition and at each subsequent interval

, they are known from calculation in previous interval . Thus the quantity ($\frac{2S_{t+1}}{\Delta t} + O_{t+1}$) can be calculated with equation (3-22) .

for impoundment storage and outflow are related and with this storage – outflow relationship , the corresponding value of O_{t+1} and S_{t+1} can be found . The computation can be repeated for O_{t+n} in successive intervals , yielding values O_{t+1} , O_{t+2},…….., O_{t+n} the required outflow hydrograph ordinates . (HEC-HMS technical reference manual 2000)

3.8 Chen Sediment Trap Method

The trap efficiency of a reservoir is the ratio of sediment deposited in the reservoir to the total sediment load income to the reservoir. The trap efficiency can be estimated by comparing critical settling velocity with settling velocity of the sediment particles (Chen,1975). The critical settling velocity is calculated as the discharge rate of the reservoir divided by surface area . The computation are performed unconnectedly for each grain size class, when the sediment is following into the reservoir , the sediment particles with settling velocity (v_s) , the critical settling velocity(v_c) is defined as the velocity allowing the particles to settle in an ideal pond . The critical settling velocity is a function of water depth (d) and water travel time through the pond (T).

$v_c = \frac{d}{T} = \frac{d}{l/v} = \frac{d.V}{L} = \frac{dvb}{lb} = \frac{Q}{A_s}$ = over flow rate ……………………...(3-23)

Where

L and b = the length and width of the rectangular settling basin

V = the water velocity

A_s =the surface area

Q = in or out flow rate

The critical settling velocity is equal to the over flow rate of the pond . The fraction of particles trapped with v_s less than v_c is given by trap efficiency (TE) is shown in the next equation

$$TE = 100 \frac{v_s}{v_c} \quad \text{for quiescent flow} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3\text{-}24)$$

Chen (1975) developed a new equation from equation (3-24) is

$$TE = 100[\,1 - e^{-\frac{v_s}{v_c}}]_s \quad \text{for turbulent flow condition} \quad \ldots\ldots\ldots\ldots (3\text{-}25)$$

The last equation was used in HEC – HMS to calculate TE , after computing trap efficiency , the sediment routing through the reservoir is calculated as shown :

$$s_d = s_i \,.\, TE \quad \ldots\ldots\ldots\ldots\ldots\ldots (3\text{-}26)$$

$$s_{sus} = s_i - s_d \quad \ldots\ldots\ldots\ldots\ldots\ldots (3\text{-}27)$$

$$s_{out} = s_{sus} \cdot \frac{Q_{out}}{V_w} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3\text{-}28)$$

Where : s_d = sediment deposited in reservoir in ton

s_i = sediment inflow into the reservoir in ton

s_{sus} = suspended sediment in reservoir in ton

s_{out} = sediment out from reservoir in ton

Q_{out} = water out flow from reservoir

V_w = water volume in reservoir

3.9 Limitations

Every simulation system has limitation due to the selection prepared in the software design. The limitation that applied in HEC-HMS4.1 are due to two aspects of the design simplified the model formulation, and simplify the flow representation . Simplifying the model formulation lets the program to do the simulation very quickly with reasonable accurate of result. The limitation that applied in the model can be expressed as follows.

• The mathematical model is deterministic so the initial condition and boundary condition must know and the program use constant parameter value.

• The basin model allows presence only one downstream connection for each hydrologic element.

• The design of process computing simulation does note allow for back water in stream network .

• Each element is computed for entire simulation time window before proceeding to next element, there is no iteration between element .

3.10 Topographic Factor Calculation

The present study adopted the formula developed by Wischemier and Smith 1965(Das, 2010) ,to calculate the topographic factor for each Subbasin:

$$L_s = \frac{(L_p)^m}{100}(1.36 + 0.97\,S + 0.1385\,S^2) \qquad \text{.................. (3-29)}$$

L_s = topographic factor

S = slope gradient factor

L_p = actual slope length.

The above mentioned theories and concepts were used in development and analysis of the sediment transport and deposition in the Himeran reservoir.

CHAPTER FOUR

CATCHMENT AREA FOR DIYALA RIVER AS CASE STUDY

4.1 Description of Himeran Dam and Reservoir

Himeran dam is located on Diyala river about 120 km northeast of Baghdad, after Derbendikan Dam construction in 1961 has been found that the flood of Diyala river not under control because of the storage in derbendikan limited on the upper part of river basin where the other part was not controlled for this reason Himeran dam constructed as gravel fill dam with clay core, the design of Dam and supervision on construction were done through Energo Project Company, the construction was finished in 1981, the project consider multi-purpose such as :

- Flood control.
- Regulation and distribution of the flow to the agricultural land.
- Hydroelectric power generation.

The dam has 40 m high with 3360 m length and the width at the Crest of dam is 8m with 107.5m as maximum design elevation, the dam has five gate each gate have width of (10.6m) and (12.5m) high, and the maximum discharge for the spillway 4000 m^3/sec at 107.5 elevation .

The reservoir has total storage of 3760 MCM the live storage is 2210 MCM.

The surface area of Himeran reservoir in squire kilometer is expressed as the function of elevation

Area = 0.298$*$ $(elevation - 80.327)^{2.22}$- 4.648 ……………………..(4.1)

Figure 4.1 show this relationship , while Figure (4.2) show Aerial photograph to Himeran reservoir.

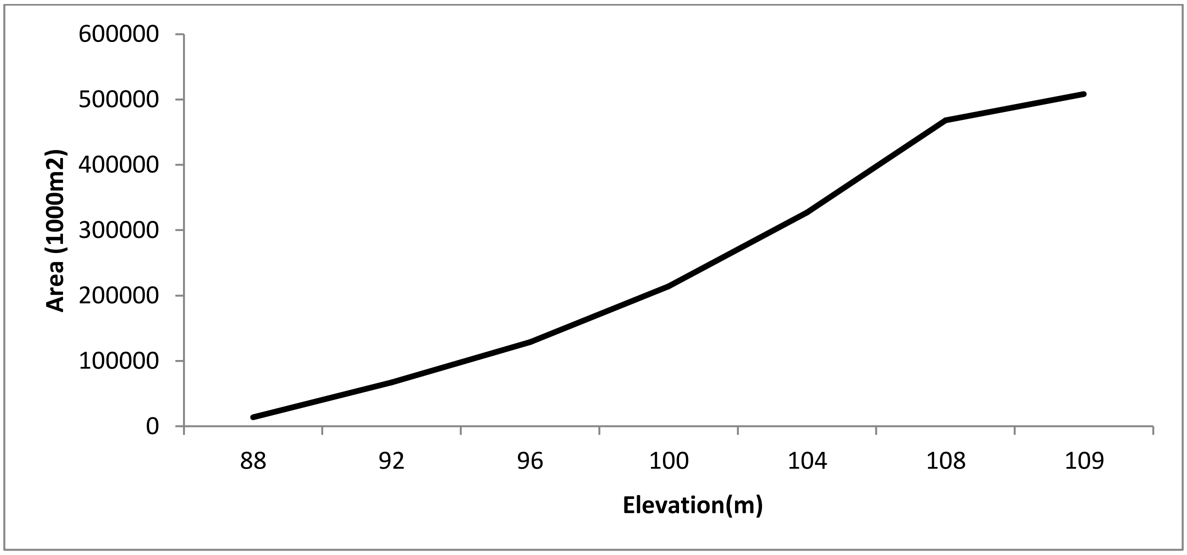


Figure (4.1) Relationship of elevation and surface area for Himeran reservoir modified after operation manual

Figure (4.2) Himeran reservoir (Google Earth January 2016)

4.2 Description of The Basin

Diyala river is considered one of the main tributaries of Tigris river, it has a drainage area of 29772 km^2 lying in the Iraq and Iran treaties.

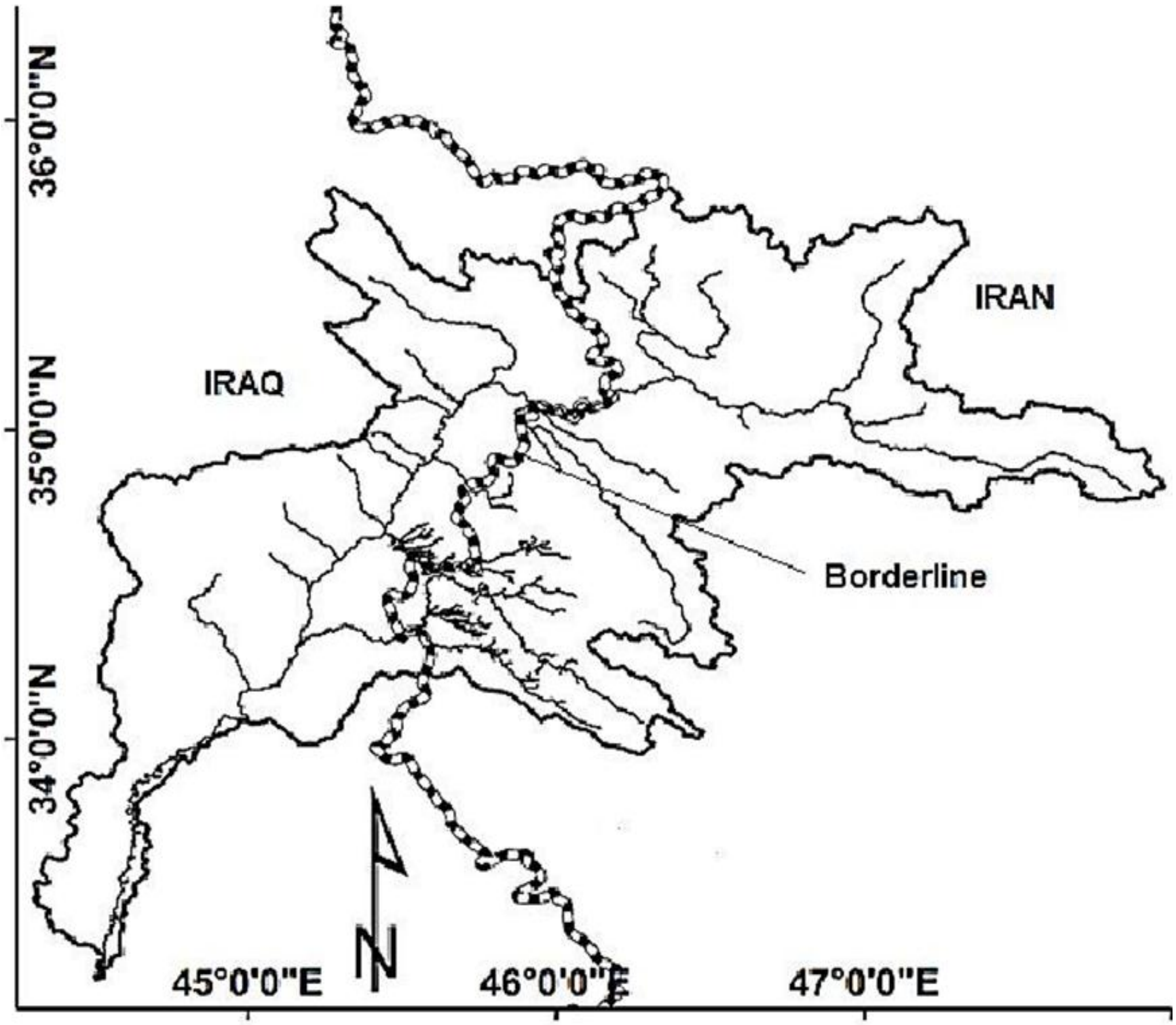


Figure (4.3) Diyala river basin after (Furat.et.al 2014)

Diyala river consist of four major basins namely above Derbendikan, Upper Diyala, Middle Diyala and Lower Diyala. Each of these basin is consist of several subbasin as listed in table (4.1).

Table (4.1) Diyala river Sub basins (Macdonald and Partners 1958)

Basin	Subbasin
Above derbendikan	Sirwan Tanjero Zinkan
Upper Diyala	Diwana Abbassan Qarato AL-Wand
Middle Diyala	Niarin Kurdarah
Lower Diyala	

4.2.1 Sirwan Subbasin

Sirwan catchment lies entirely in Iran and it is consider the largest Subbasin of Diyala river , about 40% of this catchment lie in mountain area above 2000m elevation (a.s.l).(Al-Ansari, 1987). As shown in figure (4.4).

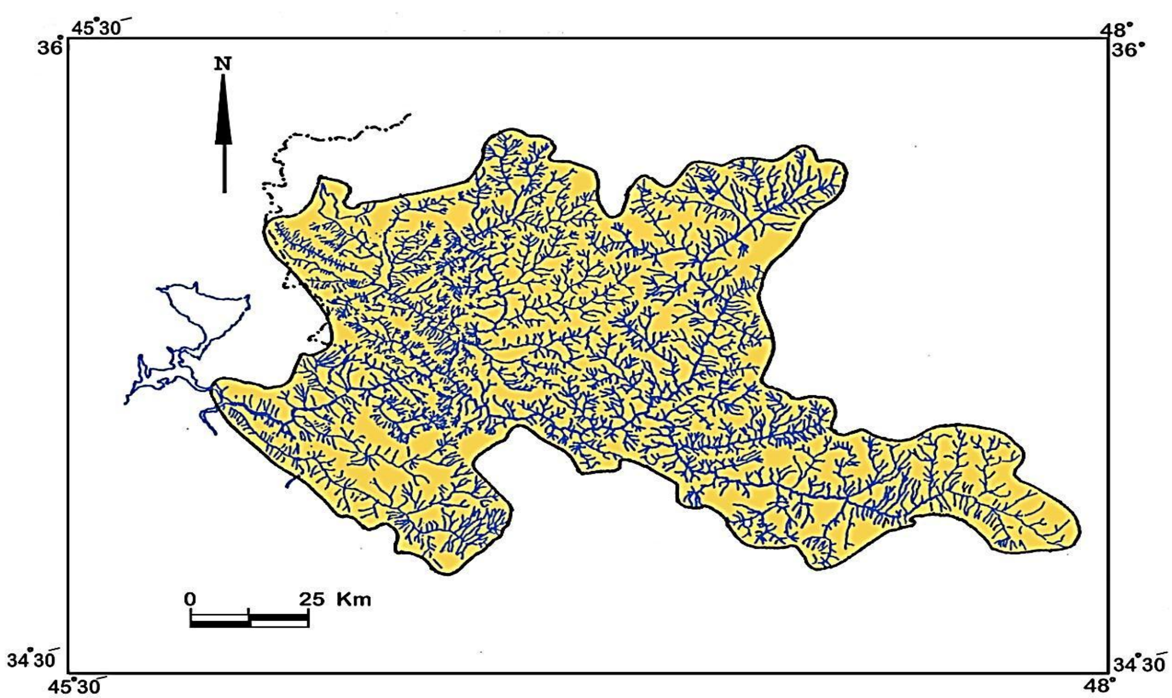


Figure (4.4) Location and shape of Sirwan Subbasin after (Al-Jubouri 1991)

4.2.2 Tanjero Subbasin

Tanjero is located at the right side of the Diyala river . It is formed out of the western slopes of high mountain along the Iraqi intercept, this catchment has a good vegetation cover therefor does not carry high sediment load to the main river . (Al-Ansari, 1987). As shown in figure(4.5).

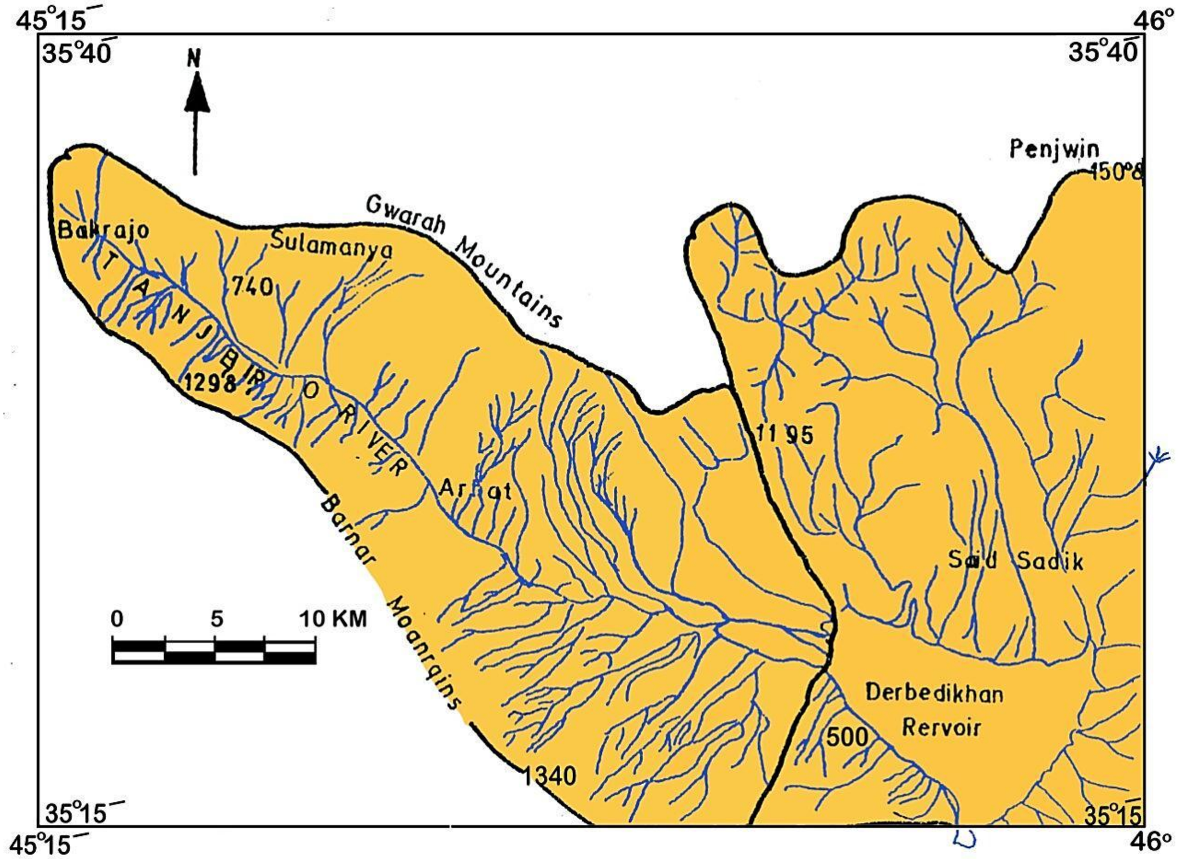


Figure (4.5) Location and shape of Tanjero Subbasin after (Al-Jubouri 1991)

4.2.3 Zinkan Subbasin

Zinkan is located at the south of Sirwan and is separated by a high mountain and it meet with Sirwan and Tanjero at derbendikan reservoir. (Al-Ansari, 1987). As shown in figure(4.6).

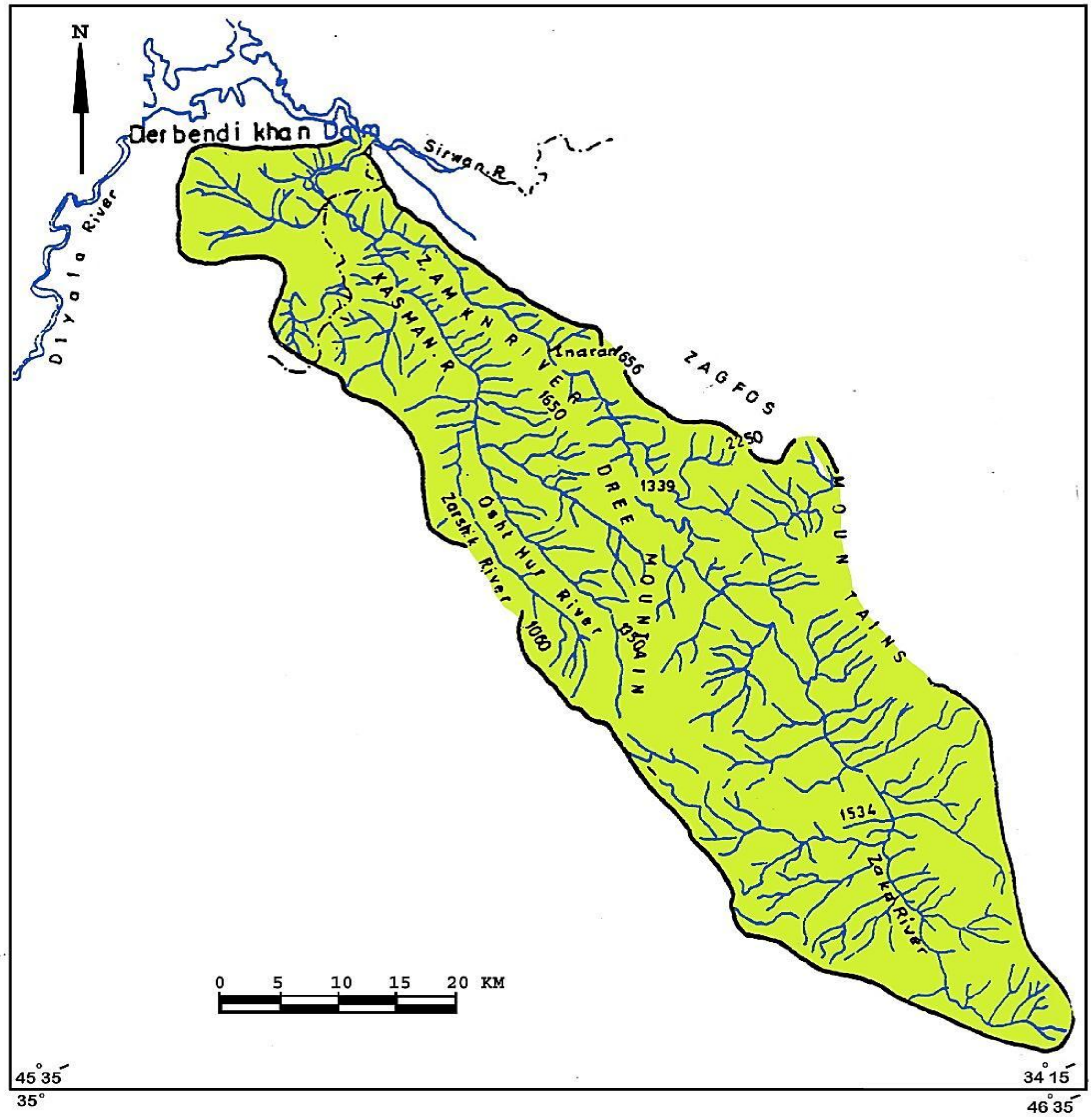
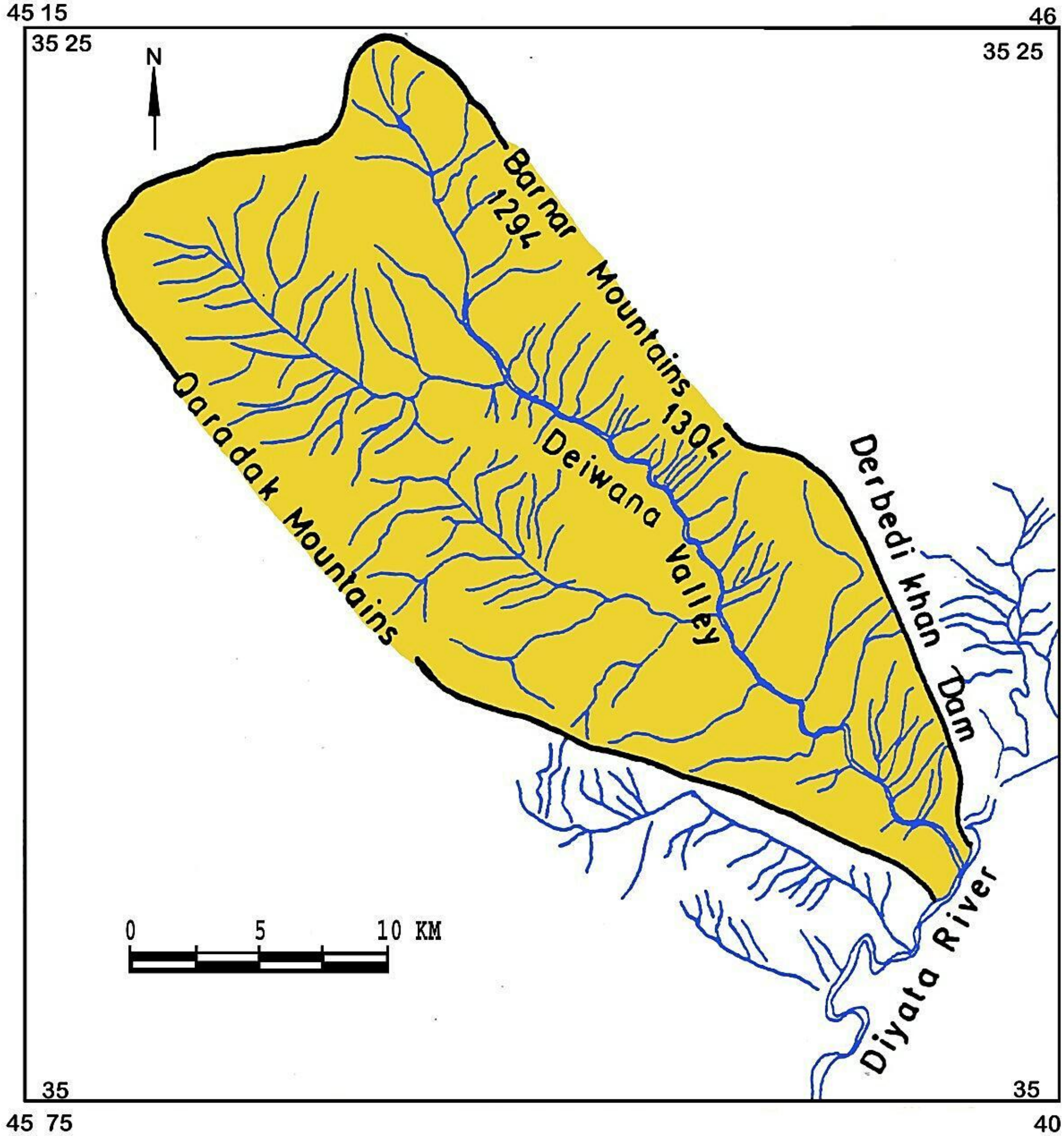


Figure (4.6) Location and shape of zinkan Subbasin after (Al-Jubouri 1991)

4.2.4 Diwana Subbasin

Diwana lies on the right bank of Diyala river, and it consider the smaller Subbasin of Diyala basin, Diwana river flow into the Diyala river directly after derbendikan dam, and the flow carries high sediment load after the heavy rain .(Al-Ansari, 1987). As shown in figure(4.7).



Figure(4.7) Location and shape of Diwana Subbasin after(Al-Jubouri 1991)

4.2.5 Abbassan Subbasin

Abbassan is located on left side of river and formed from connected of small valleys at Iraq-Iran border, and it considered one of the main tributaries of Diyala river . (Al-Ansari, 1987). As shown in figure(4.8).

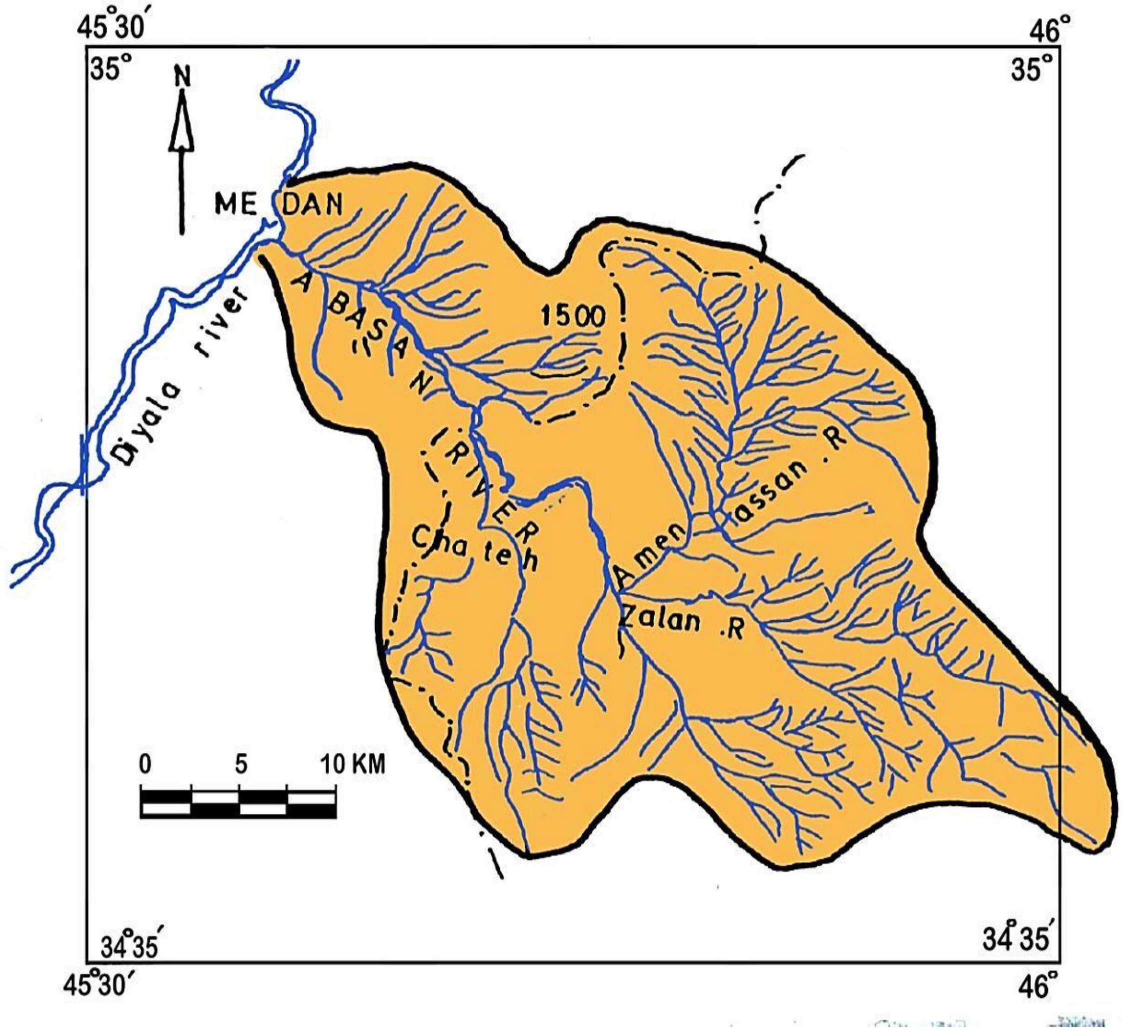


Figure (4.8) Location and shape of Abbassan Subbasin after (Al-Jubouri 1991)

4.2.6 Qarato Subbasin

Qarato same as Abbassan lies on the left side of the Diyala river, this Subbasin has an axis parallel to zakrose mountain and it has a high slope and poor vegetation cover, so that it carries large amount of sediments during flood event. (Al-Ansari, 1987). As shown in figure(4.9).

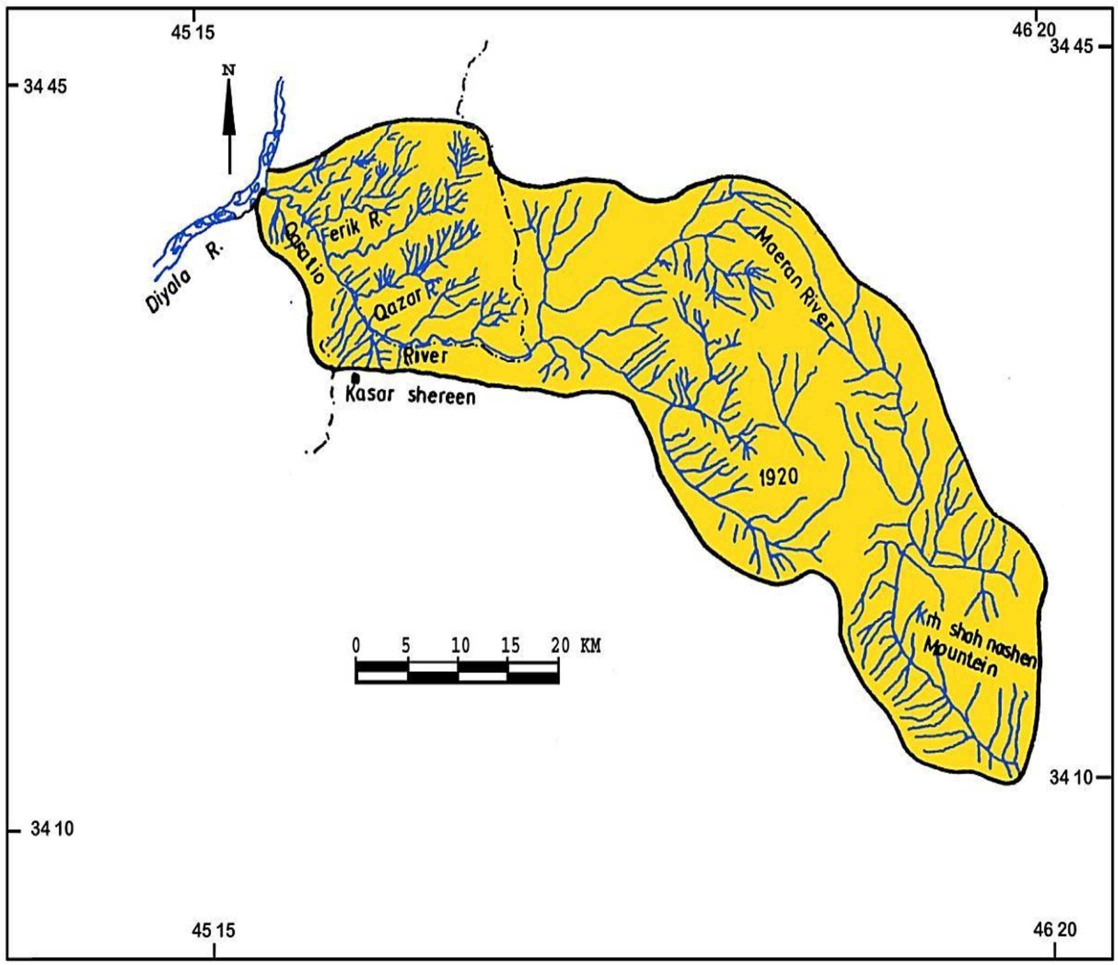


Figure (4.9) Location and shape of Qarato Subbasin after (Al-Jubouri 1991)

4.2.7 Al- Wand Subbasin

It is considered the second largest Subbasin after Sirwan Subbasin, it formed from sub tributaries in Iran area, and it is the last tributary flow into Diyala river before Himeran reservoir, it is connected with Diyala river at a distance about ten kilometer south of jalawla on the left bank.(Al-Ansari, 1987). As shown in figure(4.10).

Figure (4.10) Location and shape of Wand Subbasin after (Al-Jubouri 1991)

4.2.8 Niarin Subbasin

It is the last sub basin lying on the right side of Diyala river, it is considered as seasonal tributary . The flow of Niarin has heavy sediment load and it flow directly into Himeran reservoir. (Al-Ansari, 1987). As shown in figure(4.11).

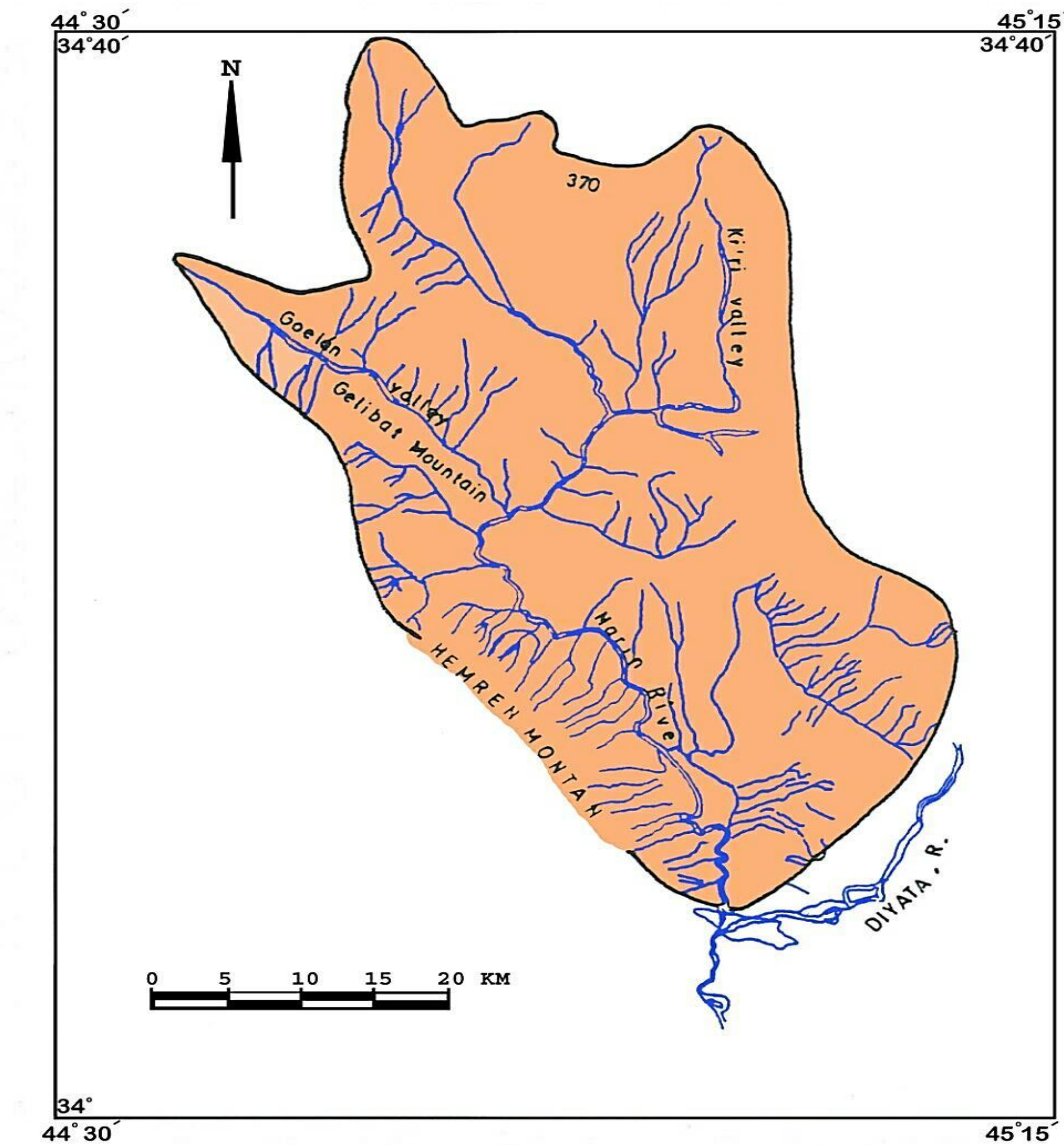


Figure (4.11) Location and shape of Niarin Subbasin after(Al-Jubouri 1991)

4.2.9 Kurdarah Subbasin

Kurdarah is the last Subbasin located on left side of Diyala river , and also considered seasonal tributary depending largely on the runoff from jabal Himeran and it also flows directly into Himeran reservoir. (Al-Ansari, 1987). As shown in figure(4.12).

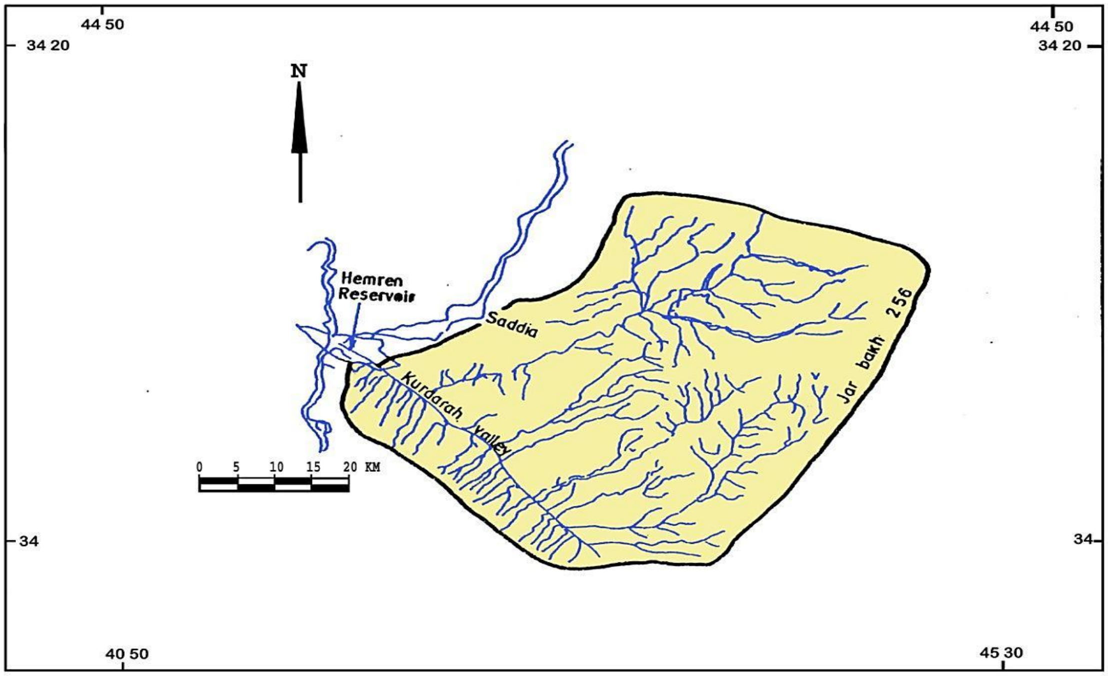


Figure (4.12) Location and shape of Kurdarah Subbasin after (Al-Jubouri 1991)

Table (4.2) Morphometric characteristic for Diyala river Subbasin as described by Al-Jubouri 1991

Subbasin	Area (km^2)	circumference (Km)	Average length (km)	Average width (km)	Max elevation (m)	Min Elevation (m)
Sirwan	10470	737	175	60	3000	400
Tanjero	925	143	58	20	1524	513
Zinkan	2306	363	115	20	3250	400
Diwana	662	115	44	15	1803	511
Abbassan	806	140	55	20	1000	390
Qarato	1906	230	100	19	1920	300
Wand	3000	318	135	22.5	2172	150
Niarin	1925	210	70	28	370	92
Kurdarah	800	108	32	25	400	90

4.3 Climatic characteristic of Diyala river basin

There are many factors which affected the magnitude and variations of the climatic element in the catchment area due to geographic position of the area, the distance from large water surface and air streaming pattern. The distribution of precipitation in the catchment area is influenced by zagros mountain along Iraqi-Iranian border. The difference in climatic element in the catchment area is the consequence of the prevailing air streaming pattern, during October to March the climate in the catchment area is greatly depended on the characteristics of the Mediterranean sea air masses, while for the period from April to September the air streaming coming from the north-west quadrant under their influence of low air pressure field above south Asia , thus the precipitation percentage for these seasons do not exceed 25-30% of total annual precipitation, the high monthly average of precipitation in the Diyala river basin occurs in the April and generally November to April consider the rainy season of the year, there is also a large fluctuation in precipitation from year to year correlating to the influence of cyclone activity in the area, the air temperature in Diyala basin is typical of continental region in SouthwestAsia in general temperature are comparatively mild winter (mean monthly temperature 15.5°) and exceptionally it is warm in summers (the average monthly temperature can reach 35°) the coldest month is January and the warmest is July, while the higher air humidity is in winter and the evaporation is consider high value in warm half of the year.(Al-Ansari, 1987).Table (4.3) show some climatic characteristic for Diyala river basin of period 1981-2014 obtained from metrological station.

Table (4.3) Some climate characteristic for Diyala basin obtain from Khanaqin meteorological station

Year	Average monthly precipitation (mm)	Average monthly evaporation(mm)
1981	34.45	20
1982	33.8	18.97
1983	18.2	17
1984	34.2	20.75
1985	29.125	20.75
1986	21.3	20.75
1987	31.9	20.7
1988	24	20.75
1989	14	21
1990	22	21
1991	33	20
1992	23.95	20.29
1993	29.63	21.1525
1994	33	21
1995	23.8	20
1996	23.5	21
1997	33	20.375
1998	22.4	21
1999	14	23
2000	24	23
2001	18.5	22
2002	30.55	20.3
2003	18.1	25.19
2004	20.05	27.64
2005	18.5	22.5
2006	17.1	22.4
2007	21	23
2008	16	29.1
2009	13.725	27.8
2010	17	29.3
2011	13.9	19
2012	25	21.25
2013	29	21

CHAPTER FIVE

MODEL CALIBRATION, RESULTS AND DISCUSSION

5.1 Introduction

The simulation processes for Himeran reservoir sedimentation was complex and spend relatively long time .The simulation was achieved using HEC-HMS 4.1, this model like other model need an input data and calibration processes, After a series of runs for model a results have been found, In this chapter modeling processes will be clarified. results interpretation have been done to explain the effects of many factors involved in the processes of sedimentation. In order to find the importance of these factors the process of sensitivity analysis for such parameters has been achieved.

5.2 Input Data

The input data are required to make sediment transport simulation for specific watershed by HEC-HMS4.1 model, the metrological data (precipitation data) is the more important input data the model need ,the precipitation data which used to made this simulation processes as is set out in table (5.1) for period (January 1981- December 2014). The total annual precipitation is shown in figure (5.1), where the maximum total annual rainfall was(413.4 mm) occurred in 1981 while the minimum value was (164.7 mm) in 2009.

Table (5.1) Total monthly rainfall (mm) for the basin (Khanaqin station)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1981	71.0	83.0	108.2	15.1	8.2	0.0	0.0	0.0	0.0	1.9	53.1	72.9
1982	67.3	94.4	14.1	66.4	5.9	0.0	0.0	0.0	0.0	30.6	81.6	46.3
1983	64.9	28.5	29.3	25.0	4.9	0.0	0.0	0.0	0.0	0.0	8.1	58.8
1984	6.6	13.2	123.4	18.1	1.7	0.3	0.0	0.0	0.0	33.7	185.8	27.6
1985	94.8	44.0	45.0	28.0	5.7	0.0	0.0	0.0	0.0	0.0	48.2	83.8
1986	15.2	63.1	15.8	36.3	27.7	M	0.0	0.0	0.0	10.2	75.0	13.3
1987	0.0	44.0	120.8	28.0	0.0	0.0	0.0	0.0	0.0	49.9	4.2	136.1
1988	68.0	62.3	51.8	39.9	0.0	0.0	0.0	0.0	0.001	9.9	6.7	57.2
1989	13.9	63.2	16.4	0.001	0.1	0.0	0.0	0.0	0.0	0.001	49.6	31.4
1990	33.7	109.1	45	26.3	5.7	0.0	0.0	0.0	0.0	0.4	12.5	15.1
1991	43.3	95.5	90.3	28	0.0	0.0	0.0	0.0	0.0	10.4	12.2	117.3
1992	62.2	69.2	65.5	8.6	8.0	0.0	0.0	0.0	0.0	0.0	18	55.9
1993	71.1	46.7	11.2	81.6	16.2	0.0	0.0	0.0	0.0	31.9	54.2	42.4
1994	71.3	13.8	47.5	22.2	5.3	0.8	0.0	0.0	0.001	52	132.3	50.8
1995	6.4	67.0	64.4	78.2	12.3	0.2	0.0	0.0	0.8	0	24.2	32.3
1996	103.8	11.9	86.9	31.8	6.5	0.0	0.0	0.0	0.0	1.9	0.5	38.8
1997	60.5	16.1	94.7	34.8	4.9	0.0	0.0	0.0	0.0	14	112.1	70.7
1998	118.3	10.5	102.7	8.6	0.001	0.0	0.001	0.0	0.0	0.001	28.8	0.001
1999	90.5	43.7	0.5	5.5	0.0	0.0	1.0	0.0	0.0	11	0.001	19.5
2000	38.7	2.7	29.0	3.2	0.001	0.0	0.0	0.0	0.001	1.4	59.3	154.4
2001	31.9	44.2	59.7	7.7	1.7	0.0	0.0	0.0	0.0	1.2	18.6	58.1
2002	105.8	41.6	55.3	61.5	0.0	0.0	0.0	0.0	0.0	7.6	39.5	55.3
2003	M	44.0	24.6	24.6	0.0	0.0	0.0	0.0	0.0	0.001	59.1	65.6
2004	89.9	21.0	4.4	9.0	20.1	0.0	0.0	0.0	0.0	0.8	73.7	21.7
2005	57.4	34.0	85.7	19.9	0.8	0.0	0.0	0.0	0.001	0.0	7.4	16.8
2006	57.4	65.4	8.0	35.8	0.0	0.0	0.0	0.0	0.0	16.9	17.7	4.0
2007	89.4	57.3	10.8	83.0	4.0	0.0	0.0	0.0	0.0	0.001	0.001	12.6
2008	52.0	16.8	8.3	0.001	0.001	0.0	0.0	0.0	0.001	78.5	37.8	4.5
2009	16.1	18.0	23.1	21.3	1.0	0.0	0.0	0.0	0.7	16.5	50.6	17.4
2010	19.4	30.7	37.9	40.3	19.6	0.0	0.0	0.0	0.0	0.5	2.4	56.1
2011	31.9	5.2	14.7	38.6	1.1	0.0	0.0	0.0	0.0	18.0	54.3	3.4
2012	11.3	45.9	25.6	4.3	3.8	0.0	0.0	0.0	0.0	29.8	170.4	10.8
2013	72.7	6.7	0.9	6.3	25.7	0.0	0.0	0.0	0.0	0.0	181.1	62.0
2014	52.1	12.1	49.1	3.8	8.9	0	0.001	0	0	43.9	54.9	31.1

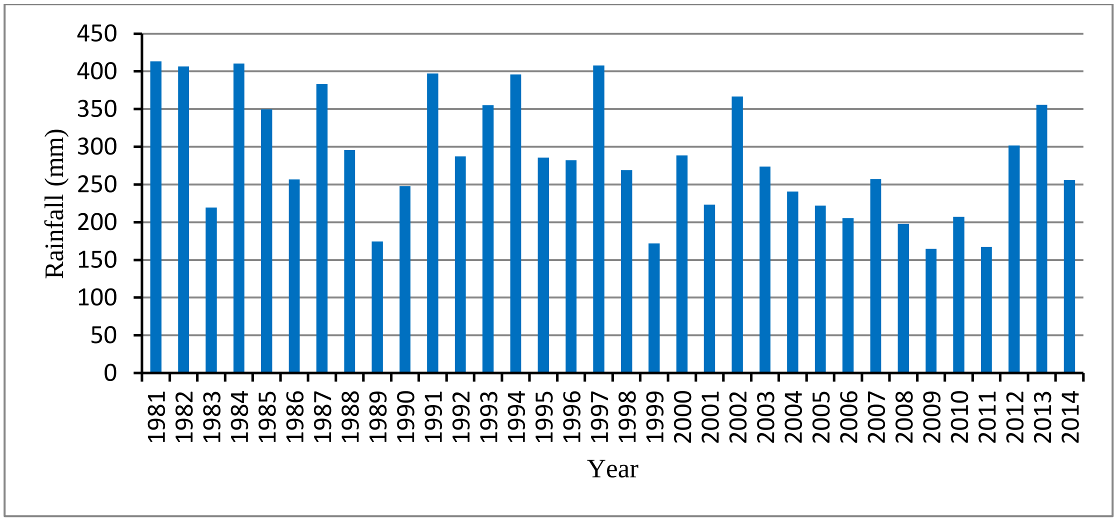


Figure (5.1) Total annual rainfall for the Diyala basin

In addition to the metrological data the model also need other input data, this input data different from element to another, these input data are described in next section:

5.2.1 Input Data For Subbasin Element

The input data needed in subbasin are included that data needed for water flow modeling and sediment transport modeling, the geometric data for subbasin is an important input data, the area of each Subbasin that used in this study as shown in the table 5.2.

Table (5.2) Area of each Subbasin in Diyala basin (Al-Jubouri 1991)

Subbasin	Area (km^2)
Diwana	662
Abbassan	806
Qarato	1906
Wand	3000
Niarin	1925
Kurdarah	800

While Soil Conservation Service transform method is used so its need to input the lag time for each Subbasin which assumed 15 min, while for calculating the volume of soil eroded from the Subbasin the model must be supplied by some of input as follows:

- Erodibility factor describes the difficulty of soil erosion. This factor is based on soil structure, texture and organic matter content, to obtain this factor the user need soil texture which is silt clay for position in the basin and assume that will not change for all Subbasin to made the modeling while the organic percent is equal to 0.6% and also assume it have one value for all the basin, after the erodibility factor had been founded equal 0.55 by using table(5.3).

Table (5.3) Value of erodibility factor (K) based on soil type and percent of organic matter content (Das 2010)

Soil type	K based on percent organic matter in soil		
	0.5%	2%	4%
Fine sand	0.36	0.31	0.22
Very fine sand	0.94	0.81	0.63
Loamy sand	0.27	0.22	0.18
Loamy very fine sand	0.98	0.85	0.67
Sandy loam	0.6	0.54	0.42
Very fine sandy loam	1.05	0.92	0.74
Silt loam	1.07	0.94	0.74
Clay loam	0.63	0.56	0.47
Silty clay loam	0.83	0.72	0.58
Silt clay	0.56	0.51	0.43

- Topographic factor describes the effect of length and slope of Subbasin on erosion. Typical value for this factor range from 0.1 for short and flat slopes to 10 for long or steep slope

The actual data for the Subbasin are shown in table 5.4.

Table (5.4) Actual topographic data for the Sub basins in Diyala basin (Al-Jubouri 1991)

Subbasin	Average length (km)	Max elevation (m)	Min Elevation (m)
Diwana	44	1803	511
Abbassan	55	1000	390
Qarato	100	1920	300
Wand	135	2172	150
Niarin	70	370	92
Kurdarah	32	400	90

The data in table(5.4) are applied to equation (3-29) to find the topographic factor for each subbasin as mentioned in in table (5.5):

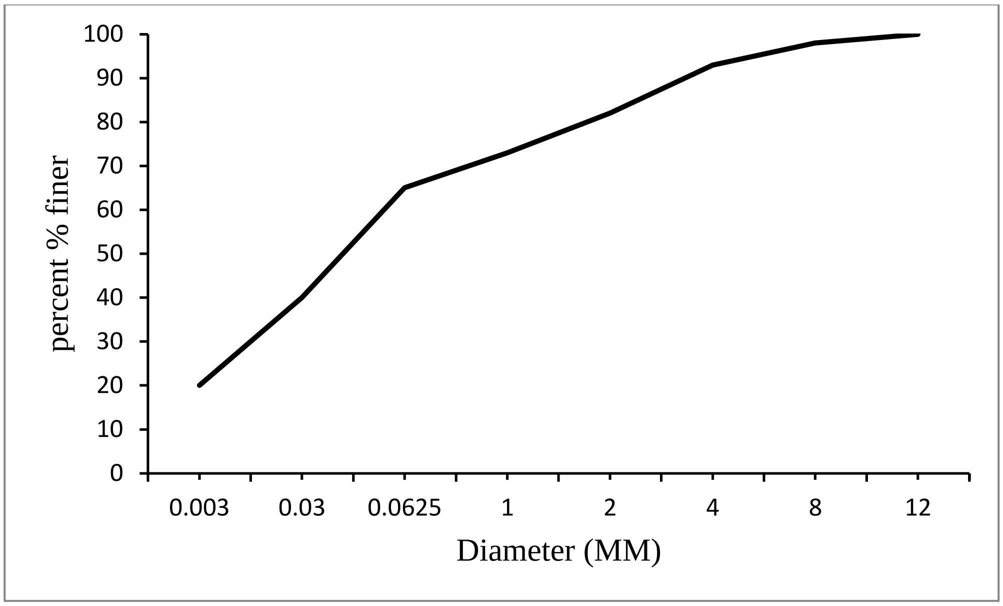
Table (5.5) Topographic factor for each Subbasin

Subbasin	Diwana	Abbassan	Qarato	Al-wand	Niarin	Kurdarah
Topographic factor	0.12	0.125	0.142	0.15	0.13	0.11

- The cover factor concerning the effect of vegetation cover on the soil erosion, the typical value for this factor ranges between 1 for bare soil to

0.1 for fully covered soil, while the soil in this study has poor vegetation cover so it is assumed that the cover factor for all sub basins is equal to 0.8.

- The graduation curve describes the distribution of sediment load in to grain size classes. The graduation curve is used to made the simulation which has been obtained from previous study of (Al-Ansari 1987)for grain size distribution in Himeran reservoir, as shown in Figure (5.2).



Figure(5.2) Size distribution curve of sediment load in Diyala basin after (Al-Ansari 1987)

5.2.2 Input Data For Reach Element

The reach element is used to model river and stream. The simulation process in reach also needs an input data. In this study Diyala river between Derbendikan dam and Himeran reservoir is divided into five reaches. These reaches are used to make the simulation of water flow and sediment transport in Diyala river, the model need an input data to be used in the simulation process, the data that used are described as follows:

- The geometric data used as input data for Diyala rive simulation are shown in table 5.6.

Table (5.6) The geometric characteristic of Diyala river that used as input data(center of studies and Engineering design)

Reach	Length(km)	Slope
Reach 1	30	0.0018
Reach 2	30	0.0019
Reach 3	30	0.002
Reach 4	30	0.0019
Reach 5	30	0.0014

Also the cross section is very important geometric input that the model need it, the cross section that used for this simulation is outlined in the table(5.7) to table (5.11) according to reach schemes in Figure (5.4). (center of studies and Engineering design).

Table (5.7) cross section of Diyala river at reach1

Distance (m)	Elevation (m)
-115	443.36
-75	414.22
0	392.31
15	378.78
17	377.46
20	377.35
25	376.59
30	376.73
49	376.62
55	376.85
85	376.69
96	399.19

Table (5.8) cross section of Diyala river at reach2

Distance(m)	Elevation(m)
-215	324.57
-190	322.89
-184	322.34
-175	322.09
-170	322.36
-155	322.71
-10	324.38
50	324.59
99	323.64
116	322.35
145	321.97
150	322.56
156	324.7
180	325.77
205	323.61
226	325.26
280	324.48
390	323.51

Table (5.9) cross section of Diyala river at reach3

Distance (m)	Elevation(m)
-40	264.07
-35	263.32
-30	262.57
-30	262.32
-25	263.52
-20	263.57
-15	264.02
-10	264.3
-5	264.86
0	265.78
60	266.21
65	266.5
80	266.52
95	265.99
230	266.81
325	266.68
330	266.94

Table (5.10) cross section of Diyala river at reach4

Distance (m)	Elevation (m)
-290	202.78
-140	202.96
-35	202.63
-20	200.68
-15	200.49
-10	200.44
0	200.19
10	199.97
25	200.45
30	200.51
45	200.91
55	201.25
60	203.09
415	203.45
420	203.49
620	204.46
1115	208.4
1150	208.62

Table (5.11) cross section of Diyala river at reach5

Distance (m)	Elevation (m)
-1159	145.2
-1156	144.51
-1155	144.9
-678	142.39
-370	141.74
-100	142.67
-30	143.1
-27	142.77
-5	142.04
10	142.31
17	142.35
30	142.6
66	144.1

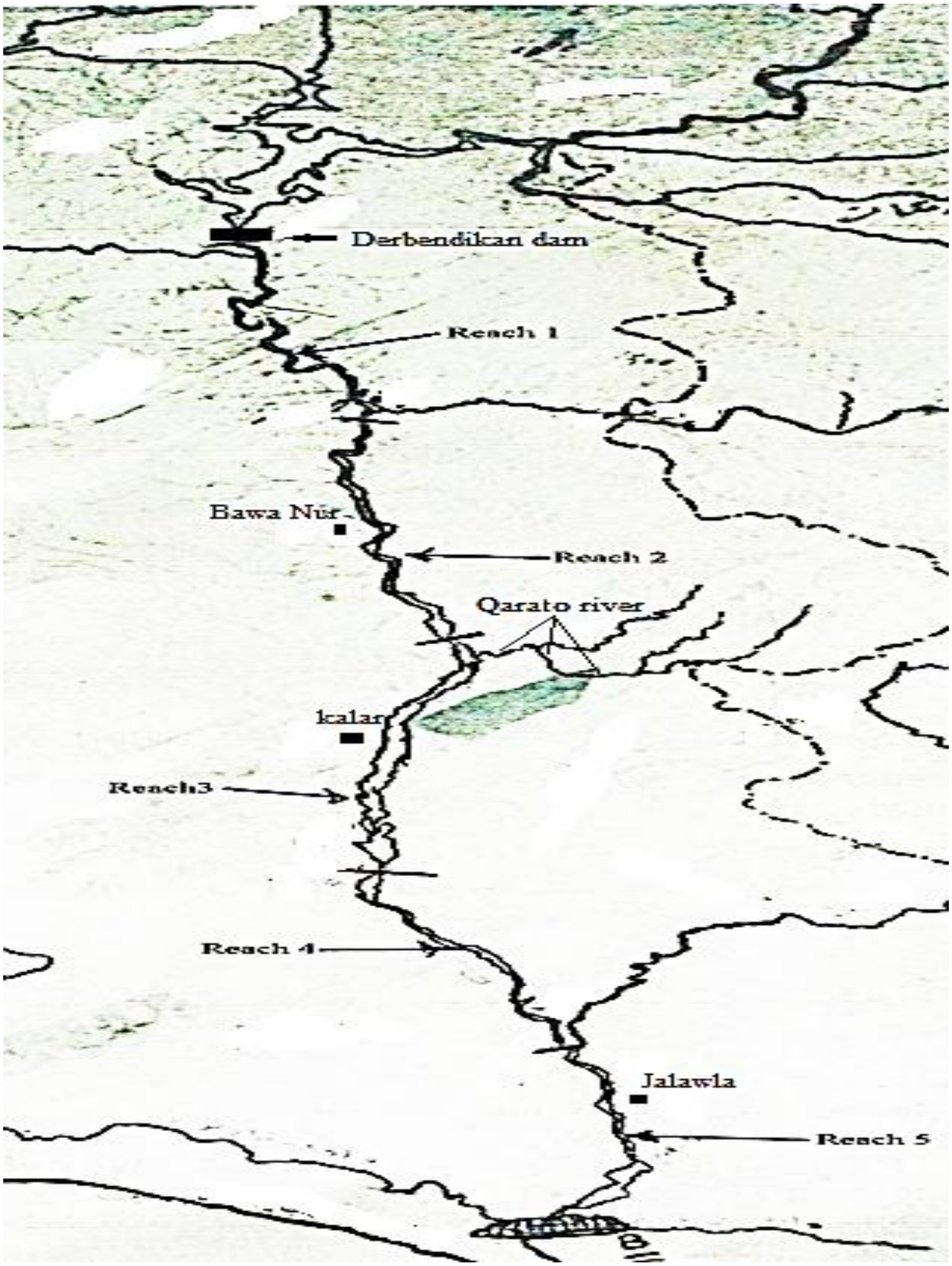


Figure (5.3) Reach Schematic for Diyala river

-Manning roughness also it is a part of input data for river, for this simulation suggest that the manning roughness(n) equal to 0.025 based on table (5.12).

Table (5.12) Manning roughness coefficient for different channel bed(Chow 1959)

Earth Channels	n
Clean	0.022
Gravelly	0.025
Weedy	0.030
Stony, Cobbles	0.035

-The grain size distribution for channel bed material is necessary to continue in the simulation process of sediment transport in the reach element, the grain size distribution curve for Diyala river bed is obtained from previous study for a limited location assuming that the river has the same bed graduation curve at all its point.

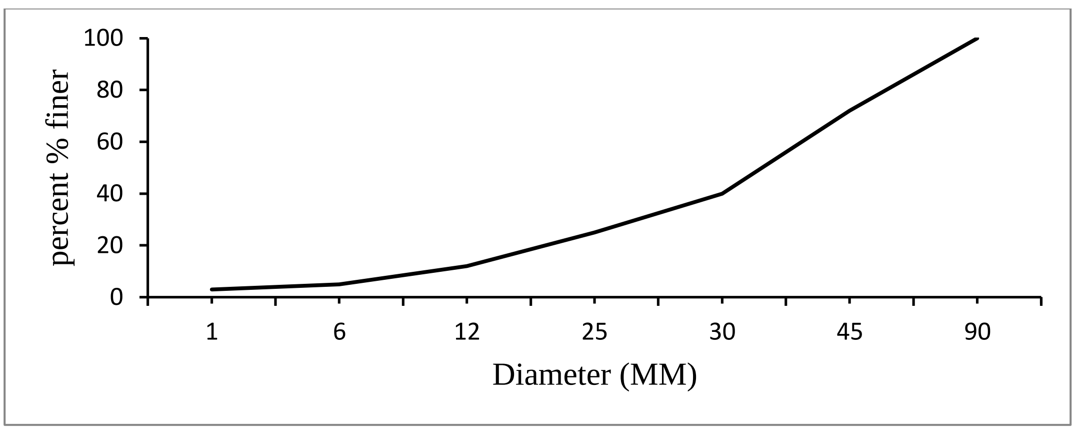


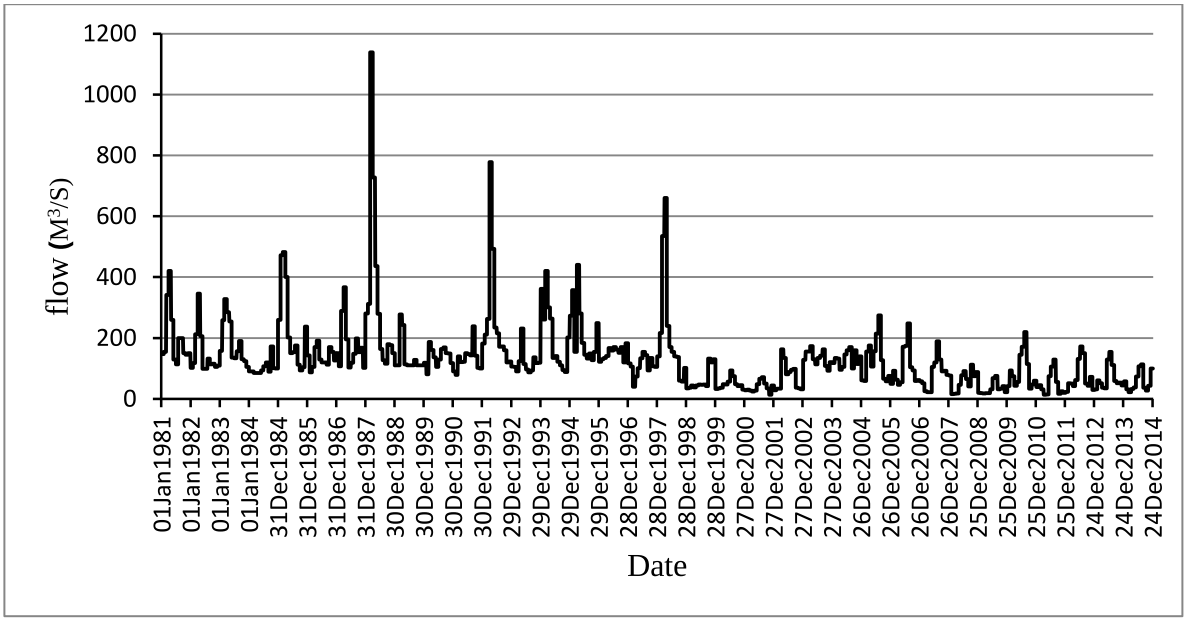
Figure (5.4) Bed gradation curve for Diyala river after (Al-Askari 2014)

5.2.3 Input Data For Reservoir Element

The reservoir element is usually with one or more inflow and one outflow, it's more important to supply the model by input for reservoir element, the input data that need in this simulation for reservoir element was focused on out flow and few other geometric boundary of reservoir, the out flow from derbendikan reservoir is very important because of its effect on the water discharge in Diyala river after Derbendikan dam which has a major role in the sediment transport in Diyala river, the out flow from Derbendikan reservoir is show in Table (5.13) and Figure (5.5).

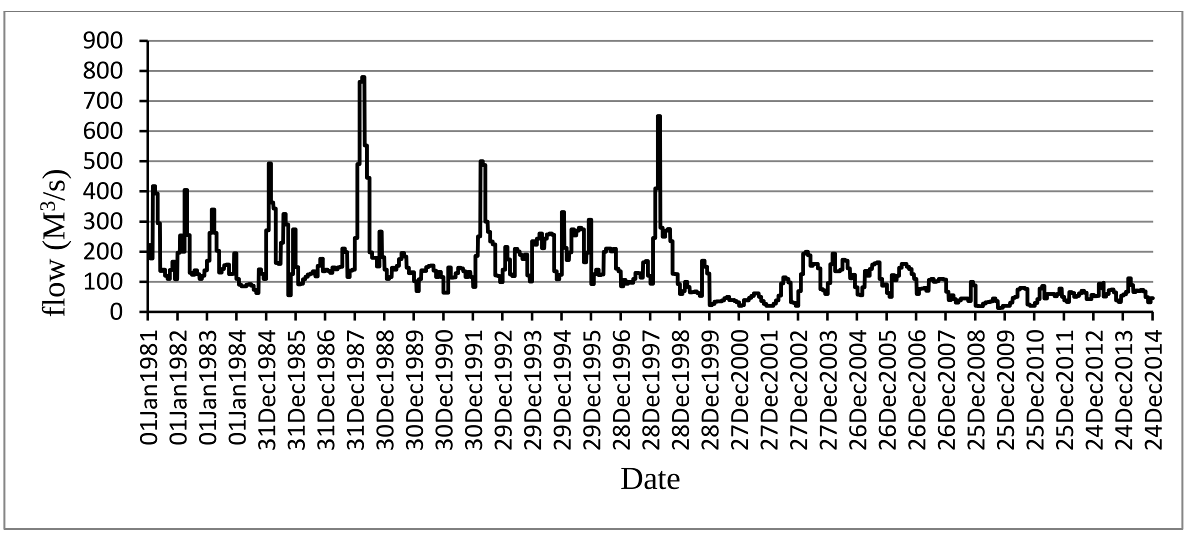
Table (5.13) Average monthly outflow (m^3/s) from Derbendikan reservoir (The National Center for Water Resources Management)

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	147	154	342	420	260	129	113	200	200	150	145	150
1982	102	118	212	346	206	99	99	132	114	116	105	109
1983	158	259	328	285	254	136	134	157	190	130	124	105
1984	90	90	85	85	85	94	107	120	89	172	101	100
1985	260	472	482	400	202	150	153	176	112	94	104	238
1986	143	87	105	170	191	129	120	120	112	94	104	238
1987	150	107	289	367	195	103	119	148	199	153	168	102
1988	281	312	1139	727	436	280	164	127	116	180	177	150
1989	110	110	277	243	114	110	110	110	128	110	110	110
1990	119	81	187	161	137	105	129	164	169	150	149	118
1991	90	79	140	121	122	150	147	143	239	142	102	100
1992	182	211	263	778	493	234	215	171	172	160	120	123
1993	106	105	90	124	231	115	97	87	94	137	118	119
1994	362	261	421	301	264	135	141	122	110	95	88	202
1995	273	357	155	440	281	184	145	132	149	27	155	249
1996	122	130	135	141	167	169	170	162	151	170	120	183
1997	117	106	40	74	101	134	154	144	94	135	107	105
1998	140	217	535	660	240	170	155	140	138	60	57	102
1999	35	37	44	38	44	47	46	47	42	132	120	130
2000	33	35	37	48	47	57	94	75	48	42	45	30
2001	28	30	27	24	27	48	66	71	50	35	14	44
2002	28	34	34	163	135	81	88	96	99	37	35	32
2003	128	156	156	173	130	114	135	142	163	108	93	121
2004	118	135	132	96	105	146	160	170	100	160	115	140
2005	61	59	156	176	106	157	214	274	127	66	58	76
2006	49	93	63	46	55	171	174	248	104	94	59	62
2007	58	51	25	22	22	105	120	189	129	90	92	79
2008	77	16	17	18	46	78	91	65	41	112	75	88
2009	20	19	18	19	19	32	68	76	32	34	42	22
2010	42	94	75	43	56	145	171	220	115	34	47	60
2011	39	45	32	14	15	75	106	129	56	17	25	20
2012	23	51	50	42	62	131	172	150	50	43	72	29
2013	32	61	51	37	35	129	155	111	59	52	54	44
2014	58	31	22	33	38	74	107	113	37	27	43	100



Figure(5.5) Outflow from Derbendikan reservoir

For Himeran reservoir which is the case study the input data required were the initial elevation (93.2 m) .The relationship between the elevation and surface area which shown in the figure (4.1), also the outflow from the reservoir is the main input as is shown in figure (5.6) and table (5.14).



Figure(5.6) Out flow from Himeran reservoir

Table (5.14) Average monthly outflow (m^3/s) from Himeran reservoir (the National Center for Water Resources Management)

year	Jan	Feb	mar	Apr	may	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	222	178	417	393	294	136	140	120	110	139	167	109
1982	197	254	200	405	255	130	123	138	125	110	120	138
1983	170	262	340	262	203	131	142	155	157	125	127	195
1984	110	91	85	85	91	93	87	74	63	141	127	110
1985	271	493	363	343	163	159	230	325	290	55	126	274
1986	149	92	94	109	117	124	128	135	118	153	176	135
1987	140	136	130	148	141	148	150	210	199	116	137	140
1988	245	491	764	779	552	445	198	180	180	151	267	182
1989	140	110	116	147	140	153	175	196	184	147	129	132
1990	102	69	109	138	136	149	153	154	137	116	133	116
1991	64	64	148	114	115	129	147	145	135	116	133	116
1992	83	186	251	500	488	300	266	234	224	121	119	99
1993	140	216	174	124	119	209	201	189	175	190	121	101
1994	235	223	243	260	211	243	257	260	256	135	109	123
1995	332	213	172	198	274	254	270	280	274	165	197	306
1996	93	125	140	122	124	200	210	210	201	209	144	135
1997	85	106	94	100	97	110	130	129	114	165	169	120
1998	94	245	410	650	280	250	270	275	235	127	125	93
1999	60	69	100	83	65	66	68	63	53	170	150	128
2000	23	27	34	35	35	38	46	50	40	40	36	32
2001	20	23	40	39	47	53	62	62	50	36	27	20
2002	20	20	28	38	54	95	115	110	98	32	30	20
2003	69	125	194	200	188	153	159	160	145	76	71	60
2004	96	158	193	135	135	140	173	170	145	112	123	82
2005	58	55	82	136	120	142	157	162	165	110	87	92
2006	63	50	122	105	120	147	160	160	150	142	125	110
2007	60	77	78	80	70	106	110	100	102	110	110	108
2008	67	40	55	43	31	38	45	45	36	100	88	83
2009	20	19	19	28	32	33	35	45	36	13	14	20
2010	20	20	31	47	50	75	80	80	77	25	20	20
2011	30	43	78	86	45	60	60	60	52	60	78	50
2012	39	33	66	63	50	53	62	70	64	43	43	56
2013	52	53	94	79	51	60	72	75	65	39	33	54
2014	59	67	112	89	66	71	69	73	68	49	32	46

5.3 Model Calibration

The model calibration process is necessary in any simulation system to have results in harmony with the actual observation, HEC-HMS suggests to use calibrated water flow before making sediment transport simulation , the calibration in HEC-HMS need to select element as computation point beside selecting the result of this element, the result selected of the same type, in this study the reach5 use as computation study and the result is the water discharge when the observation data of Diyala river is available, the calibration process also need select parameter to using it for this simulation the parameter was rate of water loss from the river. The parameter was changed many times after the initial run to model so as to obtain the best results. However the results were obtained at best when the rate of water loss was $0.005m^3$ /s/m^2 (5*10^{-4}m/s) , the best agreement is as shown figure (5.7).

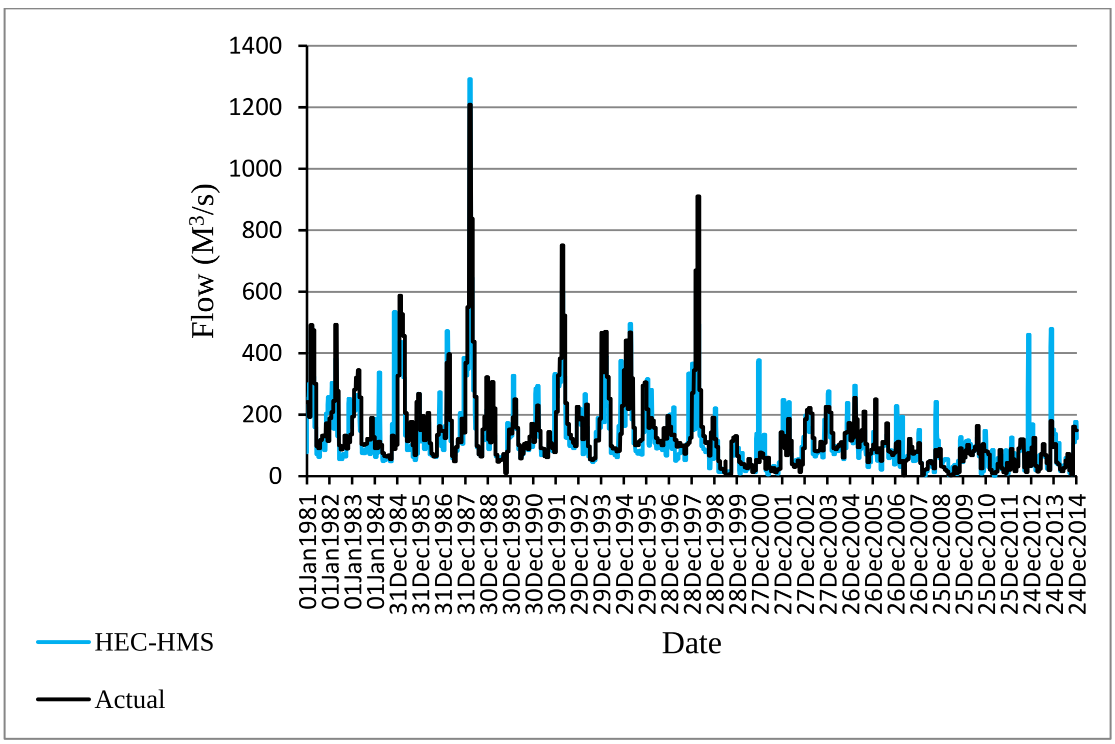


figure (5.7) Water discharge in Diyala river at reach 5

5.4 Results

The calibrated model has been run to simulate sediment transport in the basin and computing of sediment deposited in Himeran reservoir for the period (January 1981 – December 2014). The figure(5.8) shows comparison of pool elevation for Himeran reservoir.

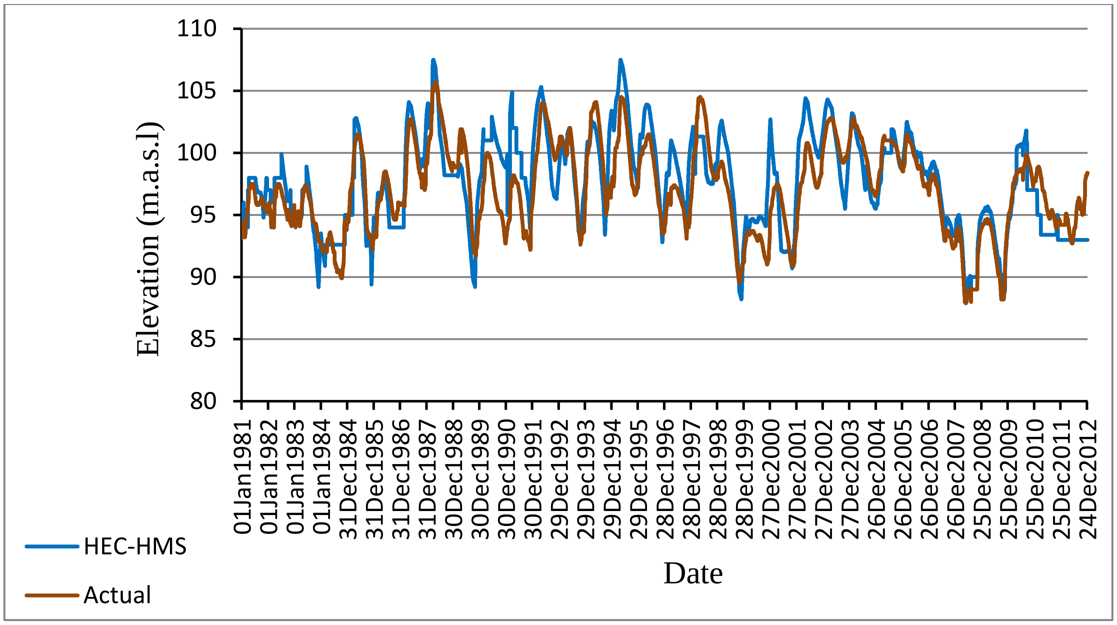


Figure (5.8) Comparison between model and actual surface elevation in Himeran reservoir

The total sediment load entering to Himeran reservoir is shown in figure (5.9) This figure show that peak sediment load occurred in November 1984 that's it was due to having the largest value of rainfall (185.8 mm) ,while table (5.15) and table (5.16) show sediment load incoming from Diyala river and the load from Niarin and Kurdarah Subbasin which directly inflow to reservoir.

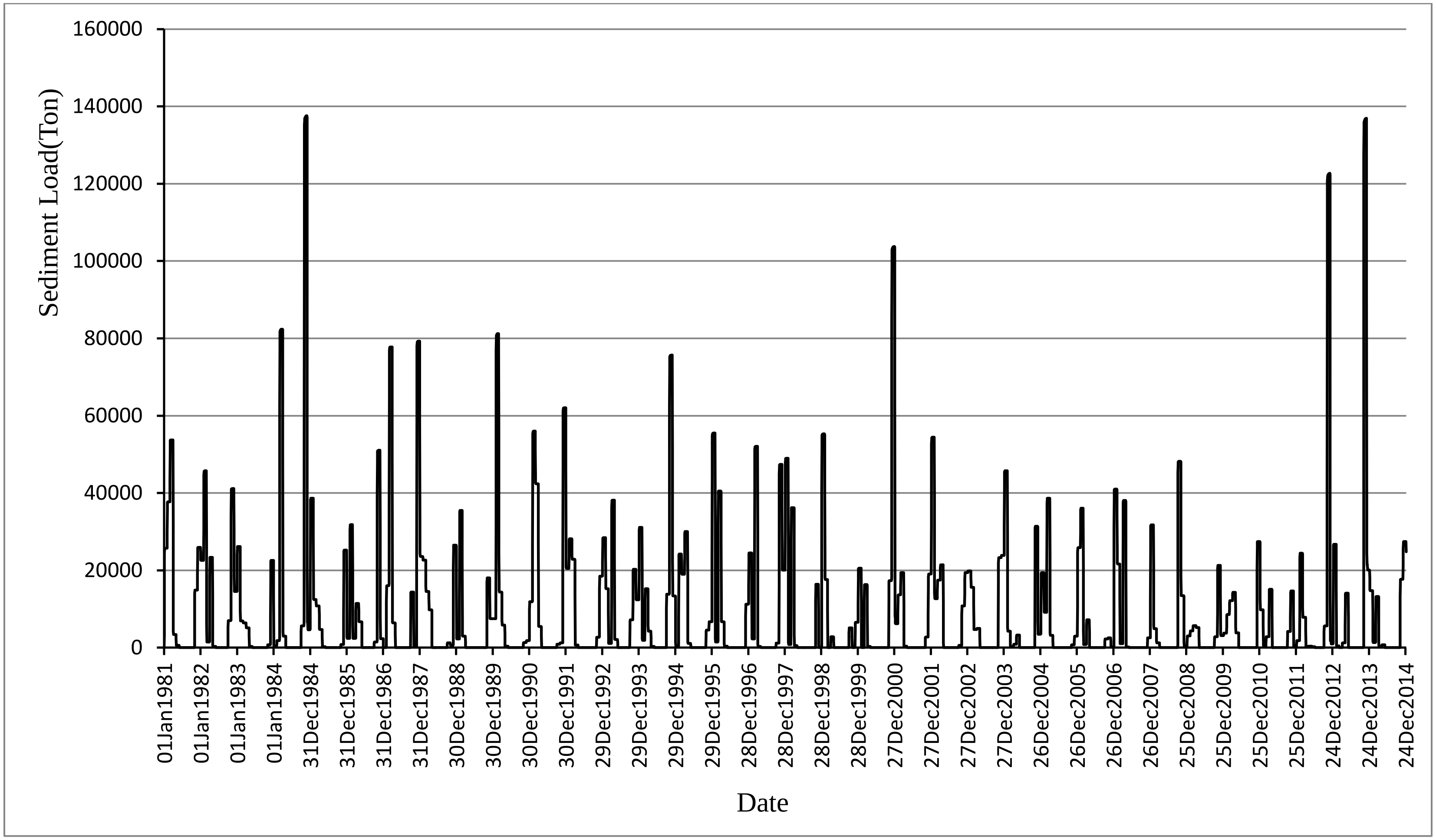


Figure (5.9) Daily sediment load entering to Himeran reservoir

Table (5.15) Total monthly sediment load(ton) entering to Himeran reservoir from Diyala river

year	Jan	Fab	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	577064.1	812392.4	1282302	107736.6	16486.5	0	0	0	0	0	332406.4	616962.6
1982	545588	978130.1	59740.6	538003.5	9884.4	0	0	0	0	161974.5	933252.8	366481.5
1983	621804.2	161416.4	154579.5	120856.4	9555	0	0	0	0	0	16735.3	527279.7
1984	23418.9	41405.3	1955878	78668.4	2441.9	0	0	0	0	131356.9	3092710	197011.5
1985	905328.9	286821.1	271363.5	113218.6	9154.1	0	0	0	0	0	18648.4	588292.3
1986	71697.6	669651.1	75425	260332.5	163887.8	0	0	0	0	34368.7	1149843	60180.9
1987	0	333086.3	1826600	191773.9	0	0	0	0	0	331972.8	11924.9	1843011
1988	605312.7	510714.6	355573.6	230609.9	0	0	0	0	0	32524.2	15516	618707.2
1989	67932.5	747166.4	90651.6	1407.8	0	0	0	0	0	0	401712.9	187298.7
1990	181316.3	1706996	390739.1	142233.6	11989.5	0	0	0	0	0	29511.9	43617.6
1991	278461.3	1185150	1030636	149254	0	0	0	0	0	20163.8	28748.1	1445072
1992	520081	628930.7	553509.3	27014.6	2563.3	0	0	0	0	0	60436.2	434406.1
1993	677625.2	339567.6	34656.5	859556	70948.5	0	0	0	0	167183.8	463144	303954.4
1994	736316.2	58064.9	357524.9	106205.6	9997.5	0	0	0	0	319308.5	1715175	362676.8
1995	14669.6	508436.6	464089	683597.1	63889.8	0	0	0	0	0	100932.9	159945
1996	1298866	64074.6	946191.6	176026.2	13048.3	0	0	0	0	0	0	259804.5
1997	581176.8	62034.5	1214948	35348.9	9555	0	0	0	0	28333.4	1068316	499948.7
1998	1158194	44625.3	845627.2	30211.9	0	0	0	0	0	0	365085.2	0
1999	1272218	407922.2	0	1003.3	0	0	0	0	0	123450.8	0	153853.4
2000	484627	387609.4	15936.3	4203	0	0	0	0	0	0	387612.7	2427222
2001	212599.6	292276.2	464229.7	18565.9	0	0	0	0	0	0	61501.9	446947.5
2002	1284947	301706.3	413559	496162.7	0	0	0	0	0	24462.7	243608.7	462349.8
2003	477310.4	342197.4	119605.3	116519.1	0	0	0	0	0		520240.5	574702.5
2004	1085937	120866.6	7800.4	19707.9	77660.9	0	0	0	0	0	700291.2	100488.6
2005	455279.2	206255.8	909731.5	93936.8	0	0	0	0	0	0	18231.3	70511.9
2006	605850.5	777238.9	39052.7	162876.1	0	0	0	0	0	54363	59391	5819
2007	954928.9	483881.1	35911.4	858045.3	24205.3	0	0	0	0	0	0	59714.8
2008	743059.5	127144.1	32757.3	0	0	0	0	0	0	1136325	318688.9	14725
2009	70889.3	94229.4	135759.4	121786.6	67299.5	0	0	0	0	67299.5	482233	85474.1
2010	90410.9	183422.3	290325.7	332249.6	98876	0	0	0	0	0	0	635048.6
2011	247511.6	15615.6	66321.2	343612.1	2599	0	0	0	0	103670.2	334480.9	12227.5
2012	43228.2	533845.1	199160.1	11959.4	8779.8	0	0	0	0	136142	2758592	97534.1
2013	624299.9	24701.3	0	28708.2	329708.4	0	0	0	0	0	3041995	567107.5
2014	359030.8	37045.2	311580.3	10127.4	17036.9	0	0	0	0	0	394567.2	651289.2

Table(5.16) Total monthly sediment load(ton) entering to Himeran reservoir from Niarin and Kurdarah Subbasin

year	Jan	Fab	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	171769.1	236560	366274.7	23818.6	4301.1	0	0	0	0	0	99756.7	178686.1
1982	158092.4	280573.8	11524.6	153281.5	2346.5	0	0	0	0	50650.2	271308.1	102289.5
1983	178753.5	43652.3	42804.3	34099.8	2082.9	0	0	0	0	0	6474.4	152881.8
1984	3925.1	17565.4	557680.5	21520.8	0	0	0	0	0	318.2	901299.5	37193.7
1985	263252.9	78521.1	74461	31274	2021.5	0	0	0	0	0	7224.1	170864.5
1986	19598.8	194392	18279.1	75771.3	45769.4	0	0	0	0	13609.3	334157.1	17068.9
1987	0	103912.3	528539	44113.6	0	0	0	0	0	97298.6	6865.7	538628.7
1988	164891.1	145945.8	100614.2	64631.1	0	0	0	0	0	8424.7	6135.9	179727.4
1989	18560.8	217073.4	21208.2	0	0	0	0	0	0	0	118634.8	52320
1990	57368.1	497650.2	100765.7	39178.8	2675.3	0	0	0	0	0	8816.5	13333.9
1991	84872.6	346671.7	290584.5	37105.6	0	0	0	0	0	6017.9	12429.6	421975.2
1992	143621	181466.2	156174.6	4774.8	0	0	0	0	0	0	19131.6	128052
1993	195143.4	94349	10617.4	249664.5	15199.1	0	0	0	0	50666.8	134409.4	87640
1994	211711.4	13760.3	103821	28630.8	2321.1	0	0	0	0	99479.9	497876.7	93314.3
1995	4247.8	145705	132184.9	198955.9	11813	0	0	0	0	0	30191.8	49826.8
1996	376152.6	13545.6	275173.3	45192.3	2829.1	0	0	0	0	0	0	78217.7
1997	166986.7	18292	352513.6	2850.3	0	0	0	0	0	11585.6	312202	141845
1998	332768.8	6020.1	245163.7	4003.7	0	0	0	0	0	0	106996.6	0
1999	375562.6	109513.1	0	18465.4	0	0	0	0	0	35835.3	0	45907.6
2000	139355.6	0	110203	2433.1	0	0	0	0	0	0	121656.2	704493.2
2001	45841.6	85571.7	132444.4	2808.1	0	0	0	0	0	0	19502.4	133630.1
2002	371487.5	80321.5	120267.7	141056.3	0	0	0	0	0	5026.8	72243.1	134213.3
2003	136863.7	96783.4	32864.3	33028.4	0	0	0	0	0	0	154238.7	166979.1
2004	311775.6	28465.6	1754.2	5937	22352.8	0	0	0	0	205545.8	26201.7	132416.3
2005	132416.3	60050.5	262778.7	21744.5	0	0	0	0	0	0	5144	22262.4
2006	178494.3	221639.3	6873.5	47056.5	0	0	0	0	0	15287.8	16898.9	4086.8
2007	279538.5	134189	10097.4	248956.4	1814.3	0	0	0	0	0	0	19807.2
2008	215791.8	32429.7	8783.3	0	0	0	0	0	0	323034.7	88991.4	2698
2009	20102.9	27380	39167	34416.7	0	0	0	0	0	20739.1	139829.9	22100.6
2010	26446	53708.7	84136.5	94902.1	26555	0	0	0	0	0	0	186708.3
2011	67676.2	3438.9	20312.2	99128	0	0	0	0	0	29822.7	96329	1729.2
2012	14273.2	155564.2	54121.9	2464.8	2517.5	0	0	0	0	46796.3	803003.2	10386.8
2013	181038.1	3537.9	0	9369.2	95325.2	0	0	0	0	0	897827.8	141538.2
2014	101168.5	8847.3	88071.4	1244.4	4909.2	0	0	0	0	0	117957.8	189424.2

The total annual sediment load entering to Himeran reservoir is show in table (5.17) and figure (5.10). The result show the largest value occurred in 1984 .The results obtained from summation of sediment inflow for all days in the year for each year. Where the average annual sediment entering to reservoir was $3.43x10^6$ ton.

Table (5.17) Total annual sediment load entering to Himeran reservoir

Year	Sediment load (TON)	Year	Sediment load (TON)
1981	4821316.5	1998	3156457
1982	4625735.2	1999	2611888.7
1983	2075832.7	2000	4768283.7
1984	7109904.2	2001	1923046.9
1985	2810959.8	2002	4154706.9
1986	3234650.1	2003	2768937.1
1987	5849495.5	2004	2720317.3
1988	3049190.6	2005	2257997.2
1989	1925990.7	2006	2194988.7
1990	3226885.1	2007	3111290.9
1991	5330774.5	2008	3056321.9
1992	2863165.9	2009	1362279.9
1993	3756031.9	2010	2098794.9
1994	4718859.3	2011	1447789
1995	2571178	2012	4878717.3
1996	3550915	2013	5943316.1
1997	4493338.3	2014	2279710.8

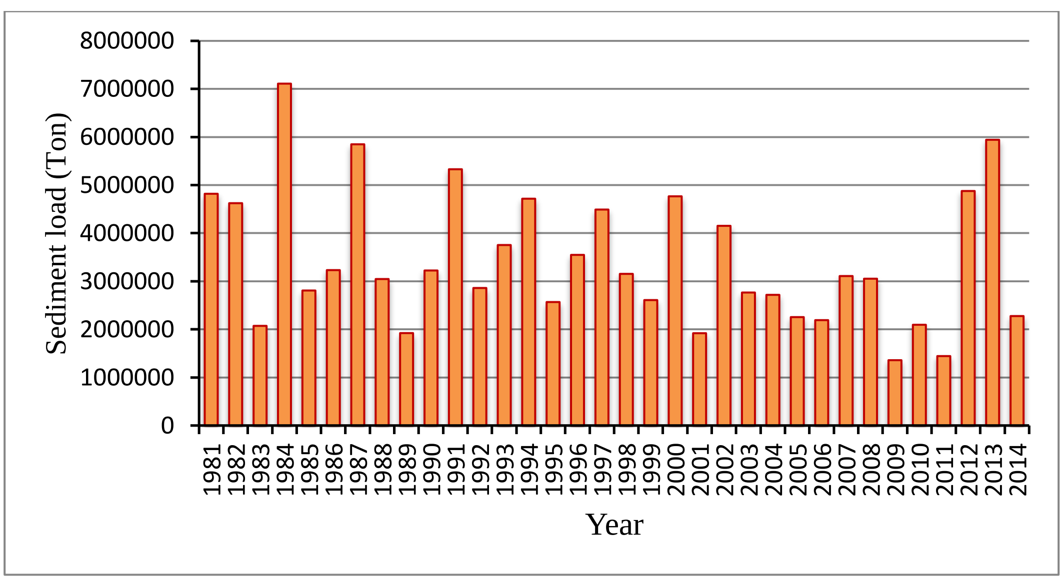


Figure (5.10) Total annual sediment load entering to Himeran reservoir

Figure (5.11) shows the sediment deposited in Himeran reservoir which consider the point which the study focused on .This figure show the amount of sediment accumulated in the reservoir for period (January 1981-December 2014) has magnitude equal to (110703592.4 TON) this means the average annual sediment deposited was $3.25x10^{6}$ton. Table (5.18)show the accumulated sediment in Himeran reservoir while Figure (5.12) to figure(5.15) show the amount of clay, silt, sand and gravel deposited.

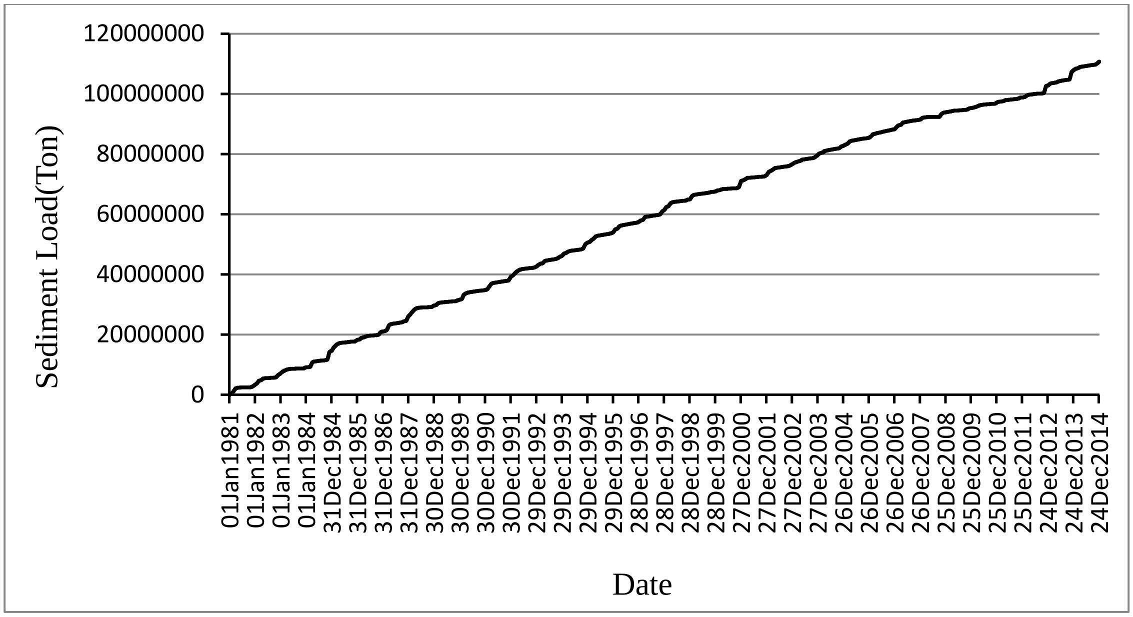


Figure (5.11) Total sediment deposited in Himeran reservoir

Table (5.18) Accumulated sediment in Himeran reservoir

year	**Sediment load (ton)**	**year**	**Sediment load(ton)**	**year**	**Sediment load (ton)**
1981	3300243.2	1993	46157943	2005	85395836
1982	7054246.2	1994	50539612	2006	88194238.6
1983	9184134.8	1995	53917644	2007	91415905.5
1984	14606990.4	1996	57450795	2008	93872956.9
1985	18258840.5	1997	61389982	2009	95289926.5
1986	21058923.3	1998	64923877	2010	97146335
1987	26045188.7	1999	67555929	2011	98809930.4
1988	29696430	2000	68647249	2012	102755330
1989	31591774.8	2001	73021657	2013	107886856
1990	34787700	2002	76613386	2014	110703592
1991	39135527.1	2003	78670962		
1992	42618960.7	2004	82725257		

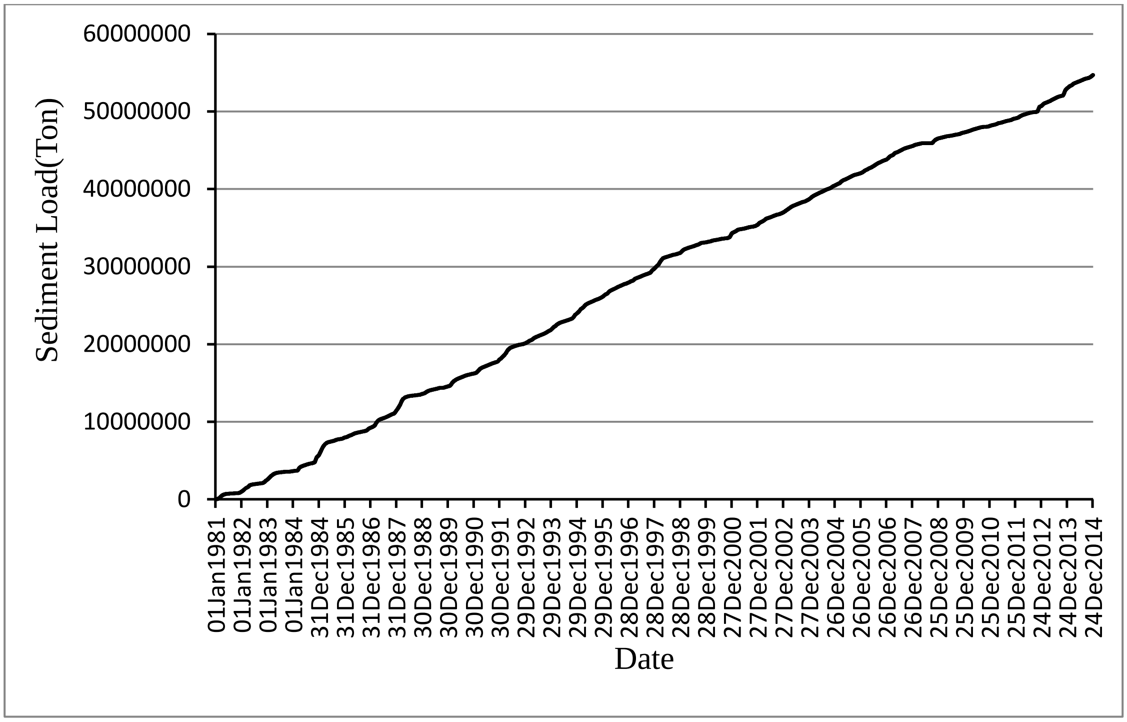


Figure (5.12) Amount of clay deposited in Himeran reservoir

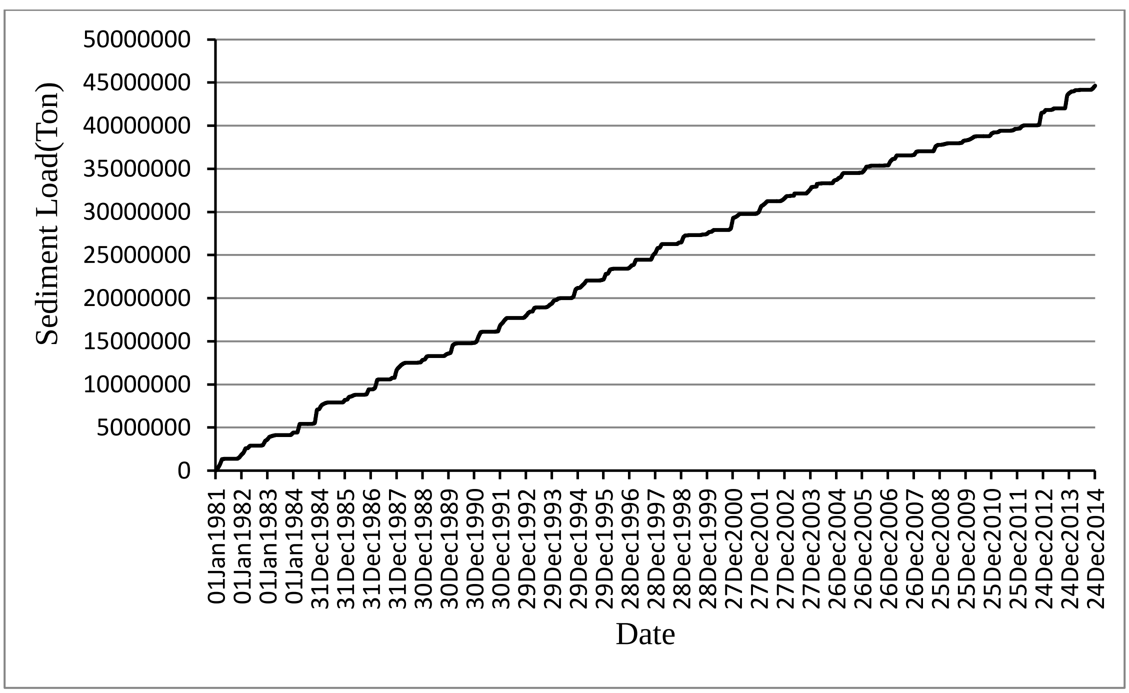


Figure (5.13) Amount of silt deposited in Himeran reservoir

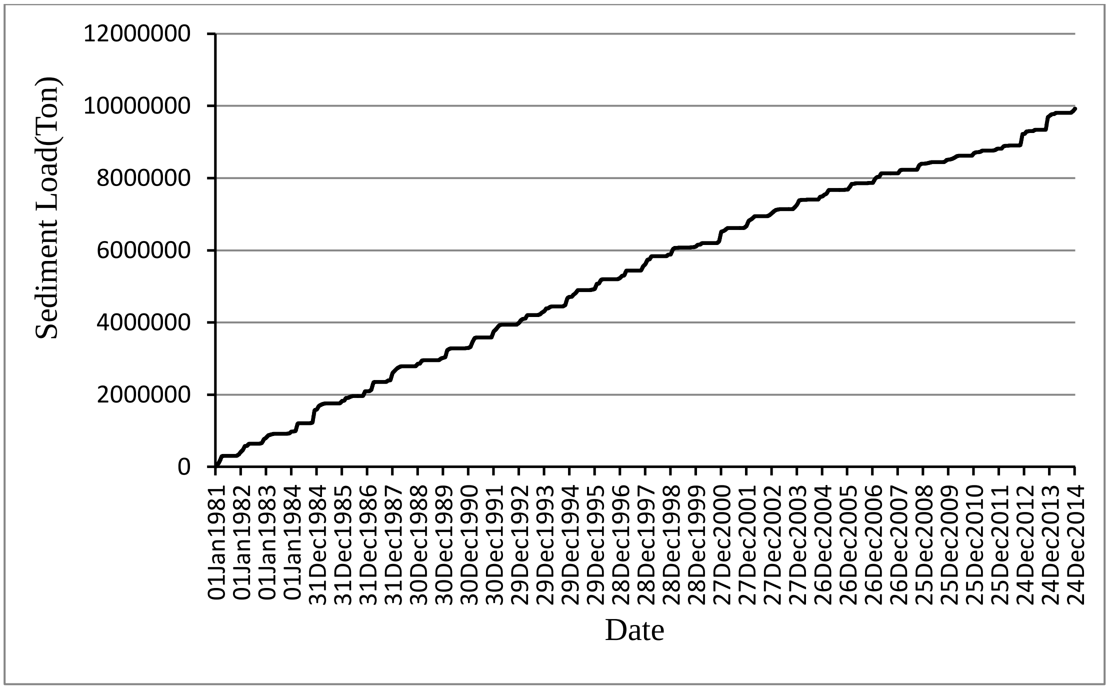


Figure (5.14) Amount of sand deposited in Himeran reservoir

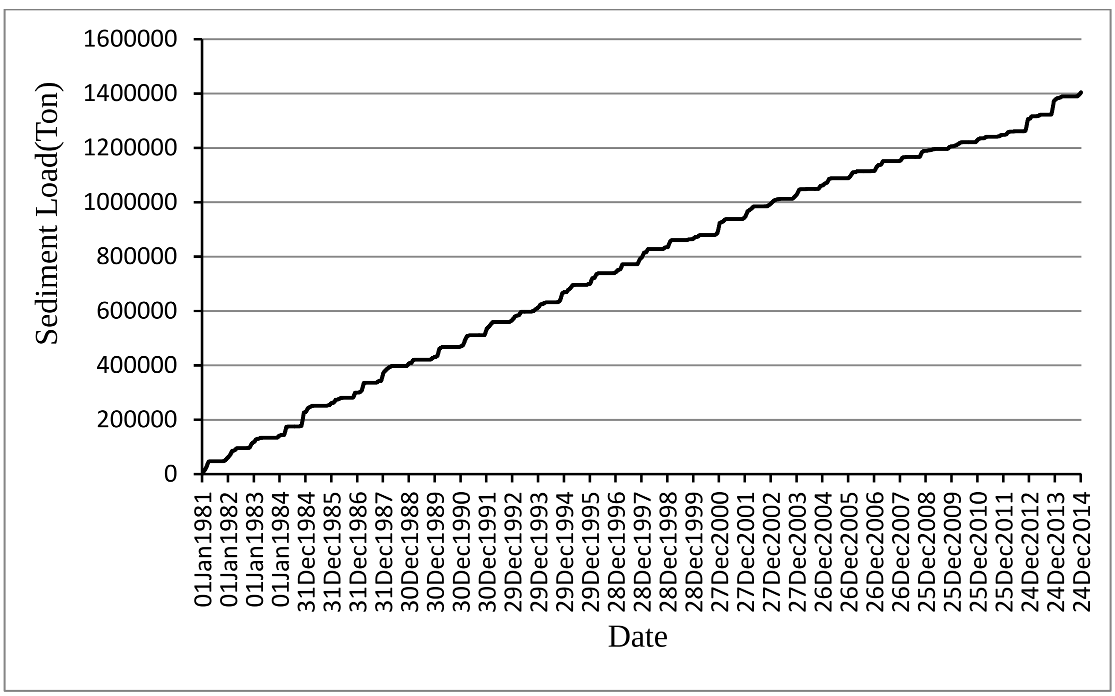


Figure (5.15) Amount of gravel deposited in Himeran reservoir

After computing the amount of sediment deposited in Himeran reservoir as mass (Ton) the volume of sediments can be founded as based on the percent of each class of sediment and its density is mentioned in the program and through the famous relationship of density, mass and volume, the result are illustrated in table (5.19).

Table (5.19) Results of sediment deposited in Himeran reservoir

Sediment class	Density (kg/m^3)	Mass (Ton)	Volume (m^3)
clay	480.55	54717527.7	113864379.8
silt	1041.2	44656462.4	42889418.36
sand	1489.7	9925081.8	6662470.162
Gravel	1489.7	1404520.6	942821.1049
			Total: 164359089.4

The total volume of sediment deposited was for 34 year in period (1January 1981 – 31 December 2014) therefore the average annual sediment deposited volume was 4.834 MCM.

Not all sediments are deposited in the reservoir some other amounts out from the reservoir. The amount of sediment out will show in figure (5.16). This figure show that the largest value occurred in March 1981 because it has large sediment inflow and water out from reservoir, it should be mentioned that all sediment load out is as clay.

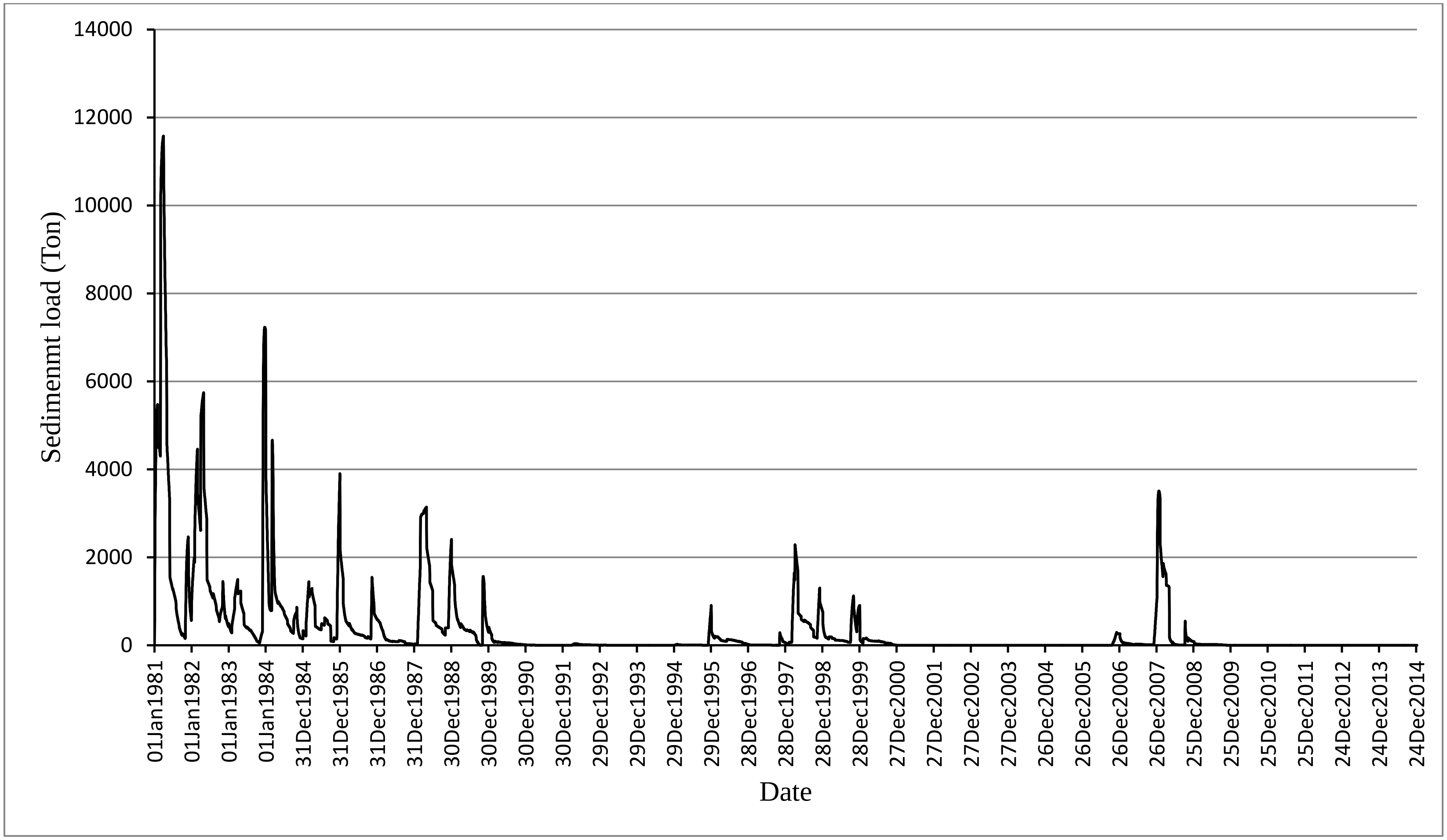


Figure (5.16) Daily sediment load out from Himeran reservoir

5.5 Sensitivity Analysis

Sensitivity analysis is a technique resorted to when there is some uncertainty in the input data of the mathematical model. By using the sensitivity analysis the modeler is enabled to know the most influential parameter. In this study the sensitivity analysis is aimed to know the parameter effect on the amount of sediment deposited in Himeran reservoir. The selected parameter in this study is the cover factor and the erodibility factor of the basin, the process is achieved by using the smaller and larger value than the initial value use in this study it is shown in table (5.20).

Table (5.20) The plan of parameter change in sensitivity analysis

Parameter	Initial value	Smaller value	Larger value
Cover factor	0.8	0.6	1
Erodibility factor	0.55	0.3	0.7

The change is done for one factor while other factors preserve this initial value for the each simulation run, the difference in the sediment inflow, out flow and deposited in the reservoir founded due to the change in parameter , this processes will describe as cases as follows:

CASE 1

The cover factor is equal to (1) while the other factor (Erodibility factor) preserves its initial value (0.55). The increase in cover factor leads to increasing in soil erosion and then increasing sediment entering and deposition in the reservoir. The results obtained from this case show in table (5.21).

CASE 2

The cover factor value is equal to (0.6) and also the erodibility factor equal to (0.55) this reduce in value of cover factor causes less soil erosion and due to this reduce in erosion the sediment income and deposition in Himeran reservoir decrease. The result of this case is set out in table (5.22).

The Figure (5.17),(5.18) and (5.19) illustrated the comparison between the results obtained from case1, case2 and the initial value of cover factor. The comparison shows that the sediment load entering, deposition and out from reservoir for case 1 (cover factor =1) is larger than the other case and the sediment load for initial value of cove factor because of the increase in cover factor which leads to increasing in soil erosion and then rising sediment entering and deposition in the reservoir.

Table (5.21) Total monthly sediment(ton) entering to Himeran reservoir with larger value of cover factor (1)

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	926749.4	1307095	2063475	173695.3	26527.3	0	0	0	0	0	534887.3	992855.5
1982	877901.9	1573803	96392.2	865881.7	15848.9					260589.1	1501556	590027.5
1983	1000660	259759.1	248755.7	194491.2	15370.6	0	0	0	0	0	26868.2	848591.3
1984	37667.9	66410	3145763	128514.5	1792.1	0	0	0	0	211005.6	4972859	321327.7
1985	1456962	461565.3	431719.6	171630.6	11172	0	0	0	0	0	29950.2	946815.1
1986	1077565	121438.8	418956.2	256825.3	0	0	0	0	0	55187.6	1850029	136105.4
1987	0	535819.7	2938526	309706	0	0	0	0	0	534261.9	8292.4	2964514
1988	975442.3	821858.9	572208.6	371121.8	0	0	0	0	0	45903.4	23638	995757.1
1989	88472.9	1202253	146054.1	0	0	0	0	0	0	0	646468.1	301377
1990	291578.8	2745446	630487.2	228895.9	19277	0	0	0	0	0	47489.4	70160.8
1991	448064.5	1906513	1606416	240421.6	0	0	0	0	0	32449.9	46099.2	2324838
1992	837671.5	1012118	890755	43439	0	0	0	0	0	0	97220.9	699062.3
1993	1090490	546465	55668.2	1383181	114285	0	0	0	0	269002.1	745339	489064.9
1994	1184971	93408.6	575388.6	170887.1	16082.7	0	0	0	0	513727.3	2759048	584815.4
1995	14358.4	818225.8	746827.1	1100055	140349.9	0	0	0	0	0	162415	257294.7
1996	2089761	103559.9	1522460	283523	20981.2	0	0	0	0	0	0	418042.1
1997	935289.3	99723.1	1954631	57480	0	0	0	0	0	45495.3	1718915	804843.2
1998	1863559	71982.7	1360923	22601.4	0	0	0	0	0	0	587525.4	0
1999	2046464	657283.7	0	101411.2	0	0	0	0	0	196992.4	0	242885.8
2000	779916.9	0	604908.2	25609.7	0	0	0	0	0	0	623472.2	3902960
2001	345365.6	470340.5	747080.7	29873.6	0	0	0	0	0	0	98957.1	719140.4
2002	2067179	486206.4	665494.9	798522	0	0	0	0	0	23283.5	391994.1	744043.9
2003	768111.3	550701.4	192442.9	187512.2	0	0	0	0	0	0	833787	924807.8
2004	1747216	194848.3	12539.7	31705.4	124985.1	0	0	0	0	0	1125021	161717.1
2005	732698.1	331875.4	1415943	151252.1	0	0	0	0	0	0	26928.2	113434.5
2006	974880.8	1250693	63001.9	262129.8	0	0	0	0	0	82678.7	95582	9300.1
2007	1536411	779066.4	57685.6	1380609	12248.5	0	0	0	0	0	0	96013.2
2008	1195611	204828.1	52715.2	0	0	0	0	0	0	1828386	513357.3	23654.5
2009	114072.6	151633.9	218470.3	195995.3	0	0	0	0	0	105074	776101	137519.1
2010	145475.9	295170.6	467202	518516.3	159088.3	0	0	0	0	0	0	1018668
2011	398353.3	25123.1	106692.4	553005.7	0	0	0	0	0	157220.8	538325.7	19628.3
2012	69507	859143.6	320483.6	19245.9	14128.1	0	0	0	0	209099.3	4435672	70716.9
2013	1004726	39727.1	0	45717.7	530616.5	0	0	0	0	0	4880085	916955.1
2014	577768	59603.2	485142	16262.8	27417.4						633751.6	1048927

Table (5.22) Total monthly sediment(ton) entering to Himeran reservoir with smaller value of cover factor (0.6)

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	557415.5	784552.7	1238385	103456.3	15916.3	0	0	0	0	0	320988.8	595820.3
1982	526715	944990.1	56988.4	509553.8	36808.4	0	0	0	0	156368.9	901669.7	353325.1
1983	600509.3	155694.2	149251.8	116692.2	9216.3	0	0	0	0	0	16122.2	509297.4
1984	22456.4	39845.2	1891383	73183.8	998.4	0	0	0	0	126620.3	2995330	181169.8
1985	874511.3	276623.7	252687.2	102968.5	8829.4	0	0	0	0	0	17970.1	568238.1
1986	69023	646926.5	72475	247266.5	158231.5	0	0	0	0	33112.9	1111386	80293.9
1987	0	321569.5	1765696	183173.3	0	0	0	0	0	320608.9	11400.3	1782254
1988	581835.8	493102.5	343242.6	222664.5	0	0	0	0	0	27541.7	14938.9	597642.4
1989	65340.7	721875.5	87108.1	0	0	0	0	0	0	0	387971.4	180752.3
1990	174948	1651721	373874.3	137296.6	11557.5	0	0	0	0	0	28493.1	42098.2
1991	268879.1	1145645	994310.3	143592.2	0	0	0	0	0	19468.5	27659.1	1396945
1992	469935.5	607354	534382.3	25949	0	0	0	0	0	0	58334.7	419527
1993	654430.6	327714.8	33337.7	830417.9	68059.4	0	0	0	0	608717.2	447301	293368.4
1994	711124.8	55861.2	345274.1	102493.3	9645.2	0	0	0	0	308288.3	1658564	347743.7
1995	14467.2	491042.8	448076.6	660092.6	61548.8	0	0	0	0	0	97455.5	1409749
1996	1255369	60613.9	914086.3	169514.7	12576.2	0	0	0	0	0	0	250857.1
1997	561307.8	59668.7	1174546	10496.8	0	0	0	0	0	27298.4	1032196	482160.4
1998	1118845	42378.8	816735.4	10992.4	0	0	0	0	0	0	352607.3	0
1999	1230026	392324	0	60854.9	0	0	0	0	0	115346.2	0	145744.3
2000	468088.2	0	363040.9	15270	0	0	0	0	0	0	374209.8	2349583
2001	199298.2	282250.7	448308.3	17803.6	0	0	0	0	0	0	59379.1	431592.1
2002	1242055	289914.9	399341.9	479130.4	0	0	0	0	0	13962.6	235234.4	446510.7
2003	460849	330377.7	115409.9	112508	0	0	0	0	0	0	500426.6	554884.5
2004	1049118	115971.3	7519.2	19022.9	74992.3	0	0	0	0	0	675315.1	96730.2
2005	439728.7	199036.9	878790.2	90283.5	0	0	0	0	0	0	16151.7	68062.5
2006	585184.9	750729.1	37229.6	157293.1	0	0	0	0	0	49607.8	57349	4698.8
2007	922673.5	466756.1	26698.5	829102.9	6185.2	0	0	0	0	0	0	57609.6
2008	717871.4	122403.4	31617.7	0	0	0	0	0	0	1098081	307017.3	14137.1
2009	68448.6	90983.8	131087	117596.2	0	0	0	0	0	63048.1	465805.4	82368
2010	87286.3	177119	280343.2	320844.5	95392.1	0	0	0	0	0	0	611496.3
2011	238746.5	15042.9	64018.4	331878.7	0	0	0	0	0	94342.7	323060.7	11703.6
2012	41707.9	515701.3	192091.8	11527.8	8476.9	0	0	0	0	125482.6	2671440	86387.1
2013	603079.3	23592.1	0	27431.7	318440.9	0	0	0	0	0	2940848	537497.8
2014	346603.4	35696.4	291141.8	9700.7	16451.5	0	0	0	0	0	380354.2	629552.9

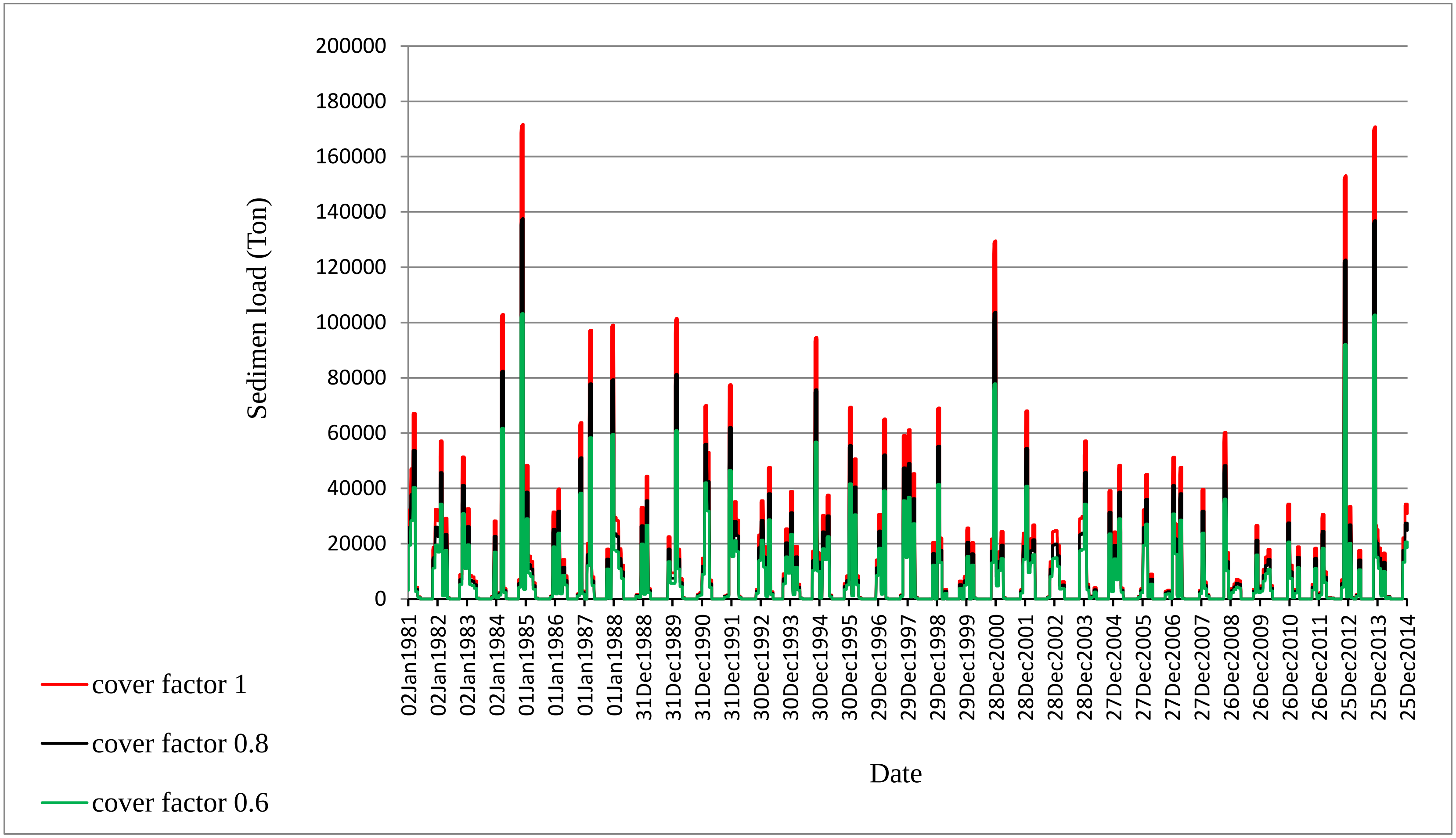


Figure (5.17) Daily sediment inflow to Himeran reservoir with different value of cover factor

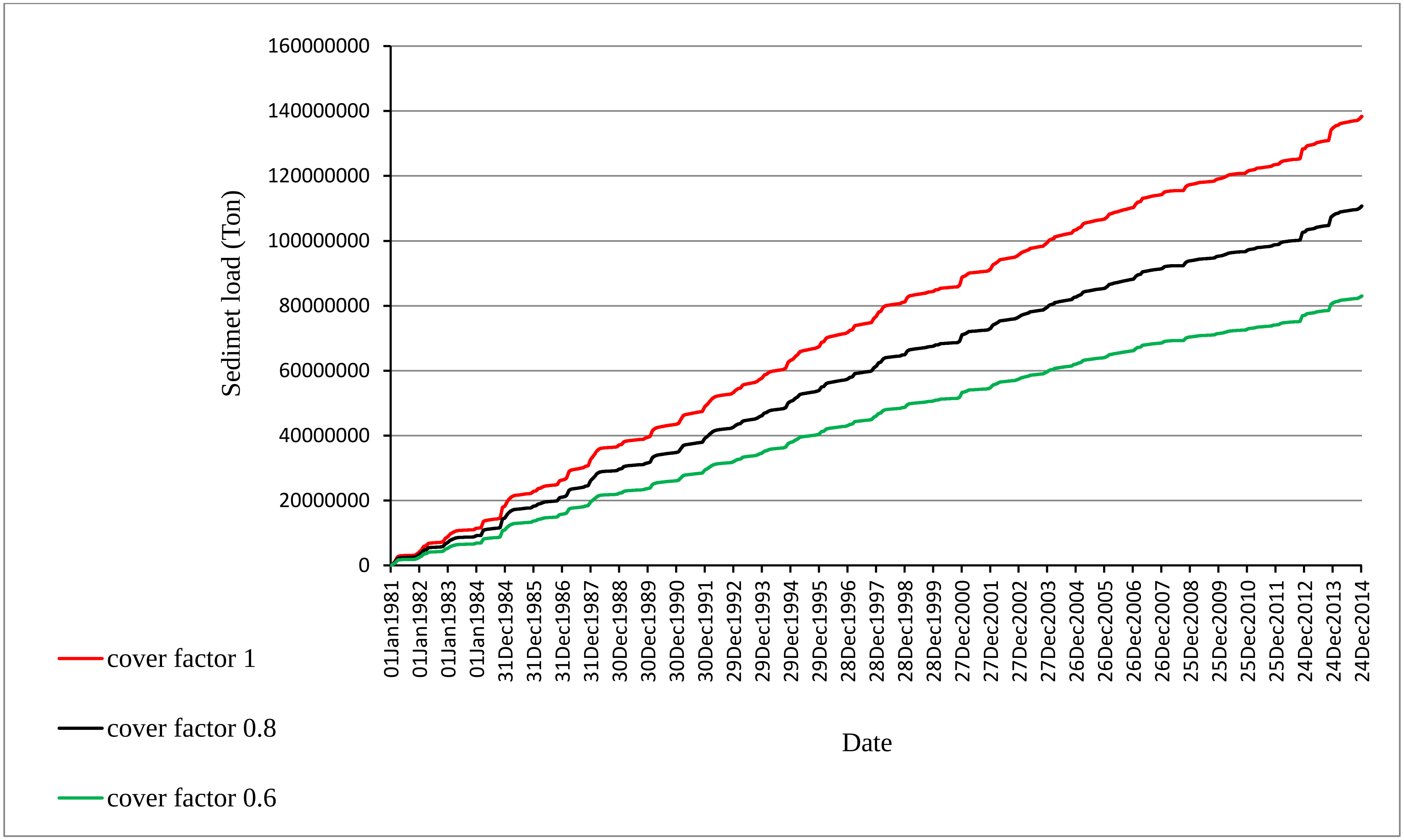


Figure (5.18) sediment deposited in Himeran reservoir with different value cover factor

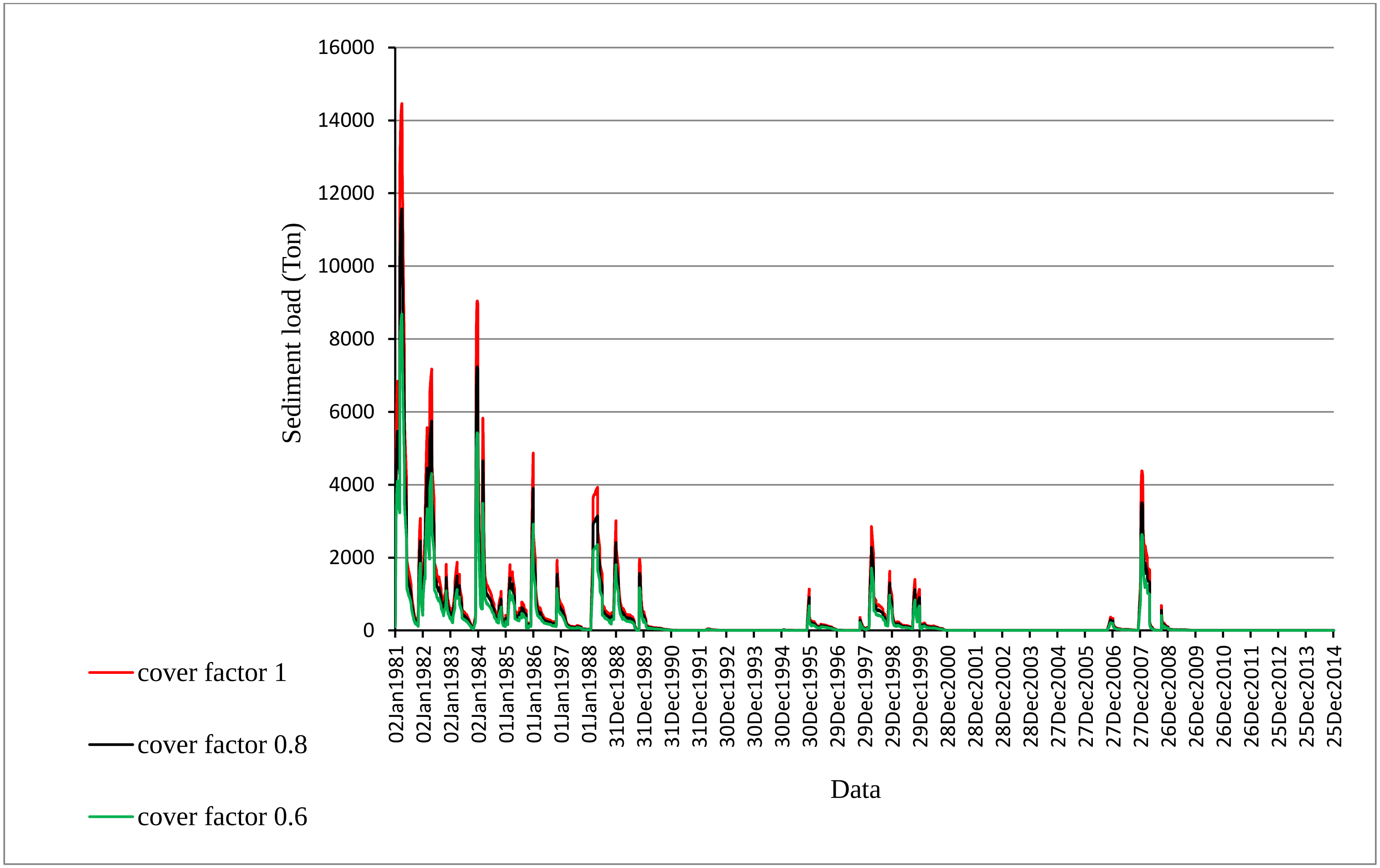


Figure (5.19) Daily sediment load out from Himeran reservoir with different value of cover factor

CASE 3

The Erodibility factor has large value (0.7) while the cover factor equal its initial value (0.8). This increase mean leaser resistance to erodibility so the erosion of soil was increased and this increasing lead to rise in sediment inflow and deposition in Himeran reservoir. The results obtained show in table(5.23).

CASE 4

The simulation run made for erodibility factor equal (0.3) for all the Sub basins while other factor still has the same value (cover factor =0.8) this reducing in erodibility factor lead to more resistance of soil erosion so the sediment inflow and deposition in reservoir decrease. The results obtained are illustrated in table(5.24).

The Figure (5.20), (5.21) and (5.22) represent a compression between the results obtained from case3, case4 and the initial value of erodibility factor. The comparison shows that the sediment load entering, deposition and out from reservoir for case 3(erodibility factor =0.7) is larger than the case 4 and the sediment load for initial value of erodibility factor because it has large erodibility factor , that means the soil have low resistance to erosion and then lead to increase the sediment entering and deposition in reservoir

Table (5.23) Total monthly sediment(ton) entering to Himeran reservoir with larger value of erodibility factor(0.7)

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	943531	1330821	2100962	176935.8	24542.8	0	0	0	0	0	544609	1010899
1982	893864.3	1602343	98232	881618.5	16143.6	0	0	0	0	265327.6	1528781	600827.9
1983	1018845	264494.4	253278.4	198027.1	15651.4	0	0	0	0	0	27356.9	864009
1984	38363.2	67617.6	3138693	195116.9	3990.7	0	0	0	0	214837.1	5062266	328182
1985	1483411	469997.1	428813.4	174751.7	15183.4	0	0	0	0	0	30496	984282.7
1986	117395.2	1097110	123693.1	412014.2	268555.2					56190.1	1883534	138712.5
1987	0	545552.5	2991711	315587.6	0	0	0	0	0	543971.6	19436.9	3018072
1988	993510.3	836803.9	582620.5	377868.4	0	0	0	0	0	46738	25348.5	1013846
1989	111215	1224054	148766.9	0	0	0	0	0	0	0	658216	306864.8
1990	296882.3	2794949	642363	233060.8	19628.5	0	0	0	0	0	48353.2	71436.4
1991	456209.2	1941014	1635716	244866.6	0	0	0	0	0	33038.3	46937.1	2366915
1992	853088.2	1030513	906955.9	44237.9	0	0	0	0	0	0	98990.2	711765.7
1993	1110298	556421.7	56686.2	1408271	116420.6	0	0	0	0	273892.9	758882.9	497962.3
1994	1206504	79100.5	585847.7	173996.8	13430.8	0	0	0	0	523063.6	2808911	595751.1
1995	15619.7	833094.3	760408.4	1120052	104708.9	0	0	0	0	0	165263.9	261971.3
1996	2127611	105589.5	1550074	288743.4	21363.7	0	0	0	0	0	0	425640.2
1997	952284.3	101550.1	1990000	58694.7	0	0	0	0	0	46321.3	1750080	819557.3
1998	1897362	73381.1	1385651	49500.1	0	0	0	0	0	0	598200.3	0
1999	2083467	669431.9	0	103254.7	0	0	0	0	0	200571.8	0	247300.3
2000	794086.1	0	615899.8	26081.9	0	0	0	0	0	0	634798	3973209
2001	352367.5	478888.2	760658.7	30425.6	0	0	0	0	0	0	100756.6	732207.6
2002	2104596	495219.2	677591.7	813040.2	0	0	0	0	0	23708.3	399120.1	757563.9
2003	782077.9	560718.9	195947.4	190920.1	0	0	0	0	0	0	848933.2	941623.7
2004	1778900	198486	12768.1	32283.9	127257.2	0	0	0	0	0	1145437	164695
2005	746010.5	337916.9	1441631	154057.5	0	0	0	0	0	0	27416.8	115498.7
2006	992573.6	1273402	64211	266893.2	0	0	0	0	0	84181.5	97318.6	9471
2007	1564263	793303.4	58746.4	1405634	39978	0	0	0	0	0	0	97758.5
2008	1217296	208605.3	53674.7	0	0	0	0	0	0	1861523	522794.9	24087.7
2009	116145.5	154390.9	222443.5	199558.2	0	0	0	0	0	106983.8	790199.7	140030.7
2010	148121	300536.5	475693.7	544423.4	161986.1	0	0	0	0	0	0	1037152
2011	405630.9	25582.3	108630.7	563054.2	0	0	0	0	0	160080.5	548108.4	19992.6
2012	70771.5	874739.5	326334.7	19597.4	14385	0	0	0	0	212897.4	4515441	164549.7
2013	1022964	40479.6	0	46548.9	540257.8	0	0	0	0	0	4967740	934690.6
2014	588278.1	60691.6	493958.6	16562.6	27916.7	0	0	0	0	0	645266.5	1067972

Table (5.24) Total monthly sediment(ton) entering to Himeran reservoir with smaller value of erodibility factor(0.3)

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	406258.5	570631	900697.2	75095.7	11575.3	0	0	0	0	0	233462.8	433354.8
1982	383057.1	687368	41304.4	370615.1	14140.4	0	0	0	0	113725.3	655880.5	256855.3
1983	436765.9	113188.4	108545.6	84864.3	6702.1	0	0	0	0	0	11725.3	370437.4
1984	16291.3	28978.7	1376252	52525	1709.9	0	0	0	0	92089.9	2180810	129372.9
1985	636092.4	201103.3	188372.6	79485.3	6421.2	0	0	0	0	0	13071.1	413307.4
1986	50155.5	470573.6	52627	182850.2	115070.3	0	0	0	0	24082.3	808476.6	58200.3
1987	0	233888.7	1284566	132774.4	0	0	0	0	0	233186.2	8275.9	1296851
1988	422519.8	358616.6	249604.1	161937.2	0	0	0	0	0	20030.9	10864.5	434702
1989	47469.3	525099	63252.3	0	0	0	0	0	0	0	282188.3	131435.3
1990	127235.2	1202154	271016.7	99839.8	8403.1	0	0	0	0	0	20721.5	30615.5
1991	195558.6	833460.7	722981.5	104310.9	0	0	0	0	0	14160.8	20117.1	1016279
1992	363825.9	441735.1	388622.9	18840.1	0	0	0	0	0	0	42425.3	305135.7
1993	475984.8	238295.9	24226.6	604043.2	49395.5	0	0	0	0	117396.7	325337.1	213340.8
1994	517221.1	40575.6	251120.8	74528.9	7016.6	0	0	0	0	224225.3	1206782	245075.4
1995	6449.2	357152.9	325867.8	480082.6	44722.9	0	0	0	0	0	70876.3	112279.7
1996	913211.9	43862.3	664903.3	123173.1	9144.1	0	0	0	0	0	0	182450.3
1997	408260.3	43351.7	854491.9	23518.1	0	0	0	0	0	19854.2	750831.8	350547
1998	813822	30674.6	594041.2	21022.6	0	0	0	0	0	0	256467.7	0
1999	894937.1	284982.8	0	44260	0	0	0	0	0	85967.8	0	105999.6
2000	340465.3	0	264056.5	11078.7	0	0	0	0	0	0	272178	1710356
2001	143353.6	205286.3	326059	12916	0	0	0	0	0	0	43185	313916.6
2002	903582.5	210560.3	290443.9	348462.7	0	0	0	0	0	10160	171090.1	324758.3
2003	335159.7	240262.9	83917.6	81823.9	0	0	0	0	0	0	363989.1	403552.1
2004	763102.3	84193.3	5339.5	13834.7	54541.1	0	0	0	0	0	491209.9	70279.2
2005	319834.3	144730	639213.9	65560.8	0	0	0	0	0	0	11750.7	49500.3
2006	425648.9	26971.4	114400.6	0	0	0	0	0	0	36076.9	41709.8	4058.7
2007	671167.7	339365.9	25030.2	603107.7	16439.6	0	0	0	0	0	0	41897.9
2008	522179.5	88933.6	22992	0	0	0	0	0	0	798778.8	223127.7	10265.5
2009	49783.4	66171.8	95336.8	85523.4	0	0	0	0	0	45852.8	338808.2	59862.7
2010	63480.2	128818.4	203894.2	233347.4	67265.3	0	0	0	0	0	0	444792.1
2011	173576.9	10932.1	46561.2	241387.8	0	0	0	0	0	68616.1	234971.1	8489.5
2012	30333.8	375110.7	139653.7	8378.2	6165	0	0	0	0	91262.3	1944920	60768.6
2013	438663.9	17098	0	19951.6	231613.2	0	0	0	0	0	2141501	388239
2014	252060.4	25943.6	211754.9	7039.5	11964.6	0	0	0	0	0	276649.9	457888.2

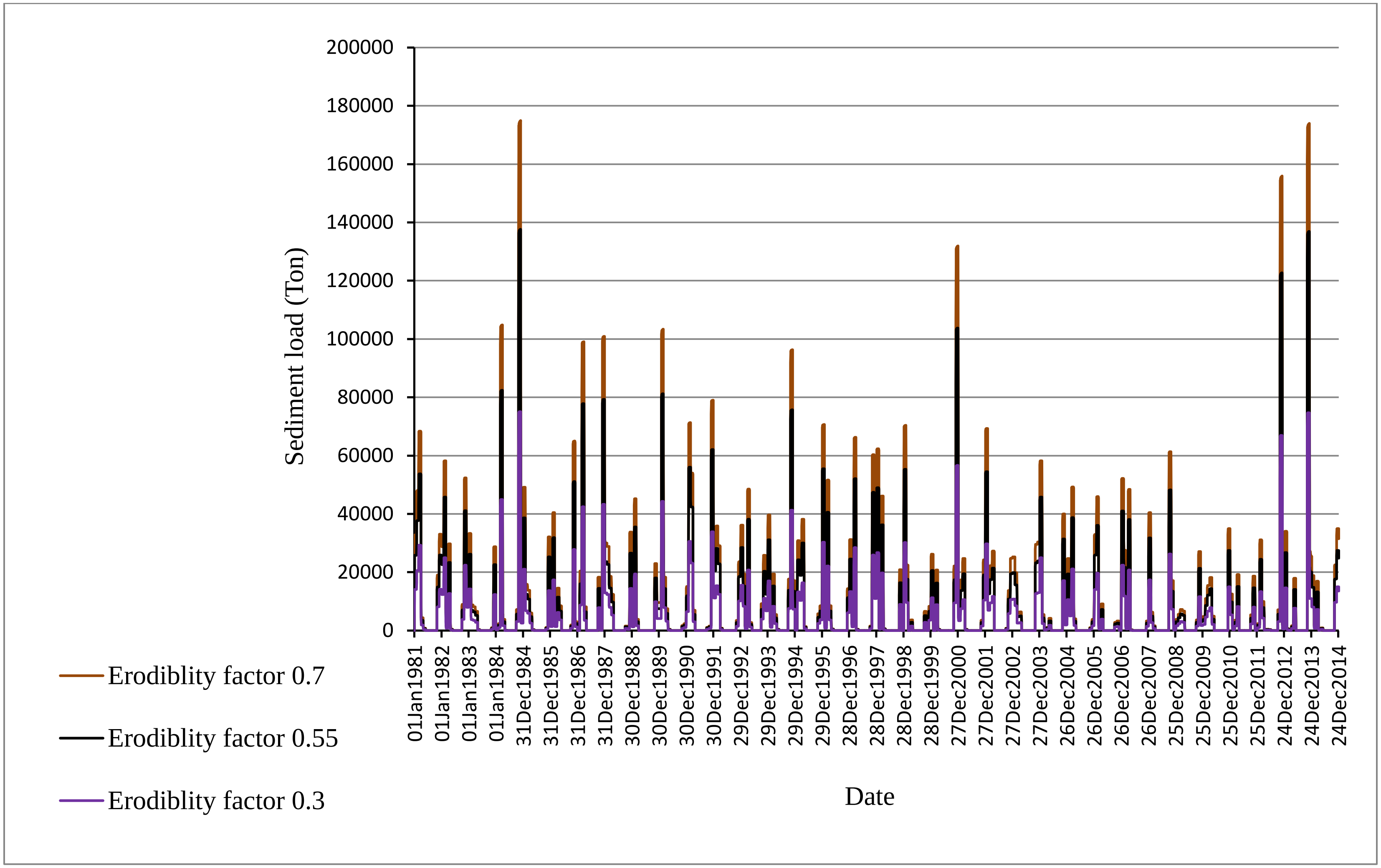


Figure (5.20) Daily sediment inflow to Himeran reservoir with different value of erodibility factor

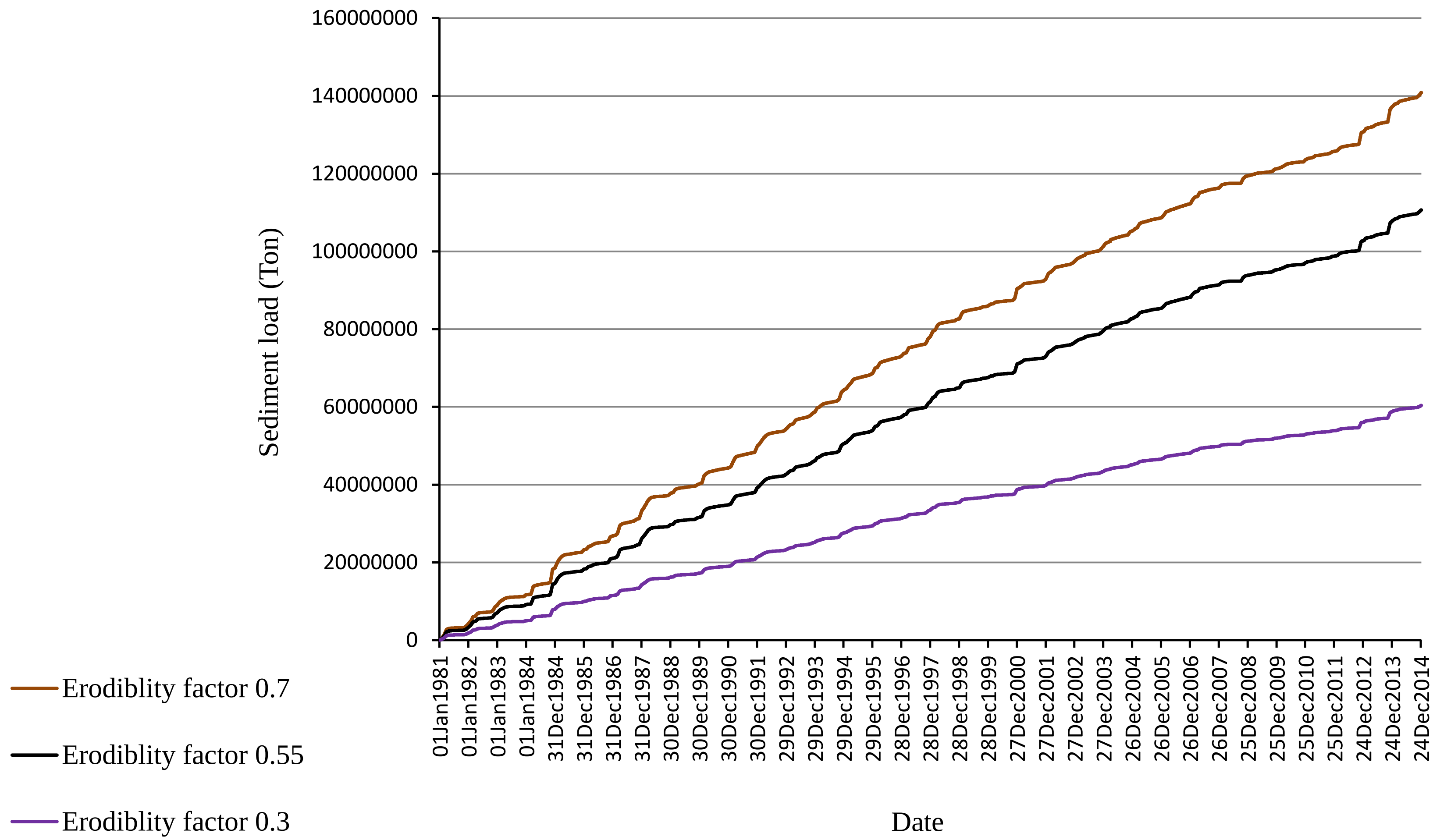


Figure (5.21) Sediment deposited in Himeran reservoir with different value of erodibility factor

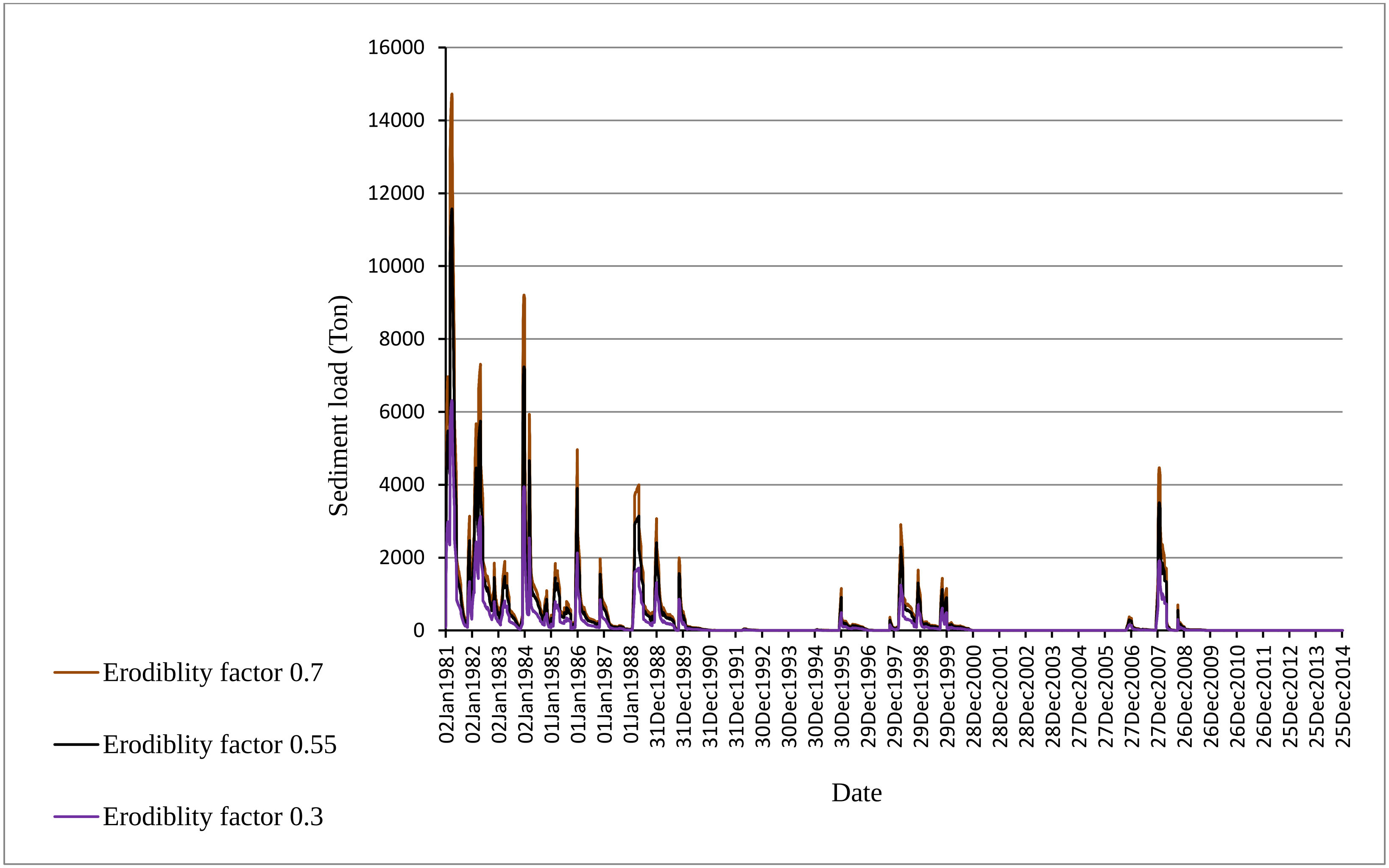
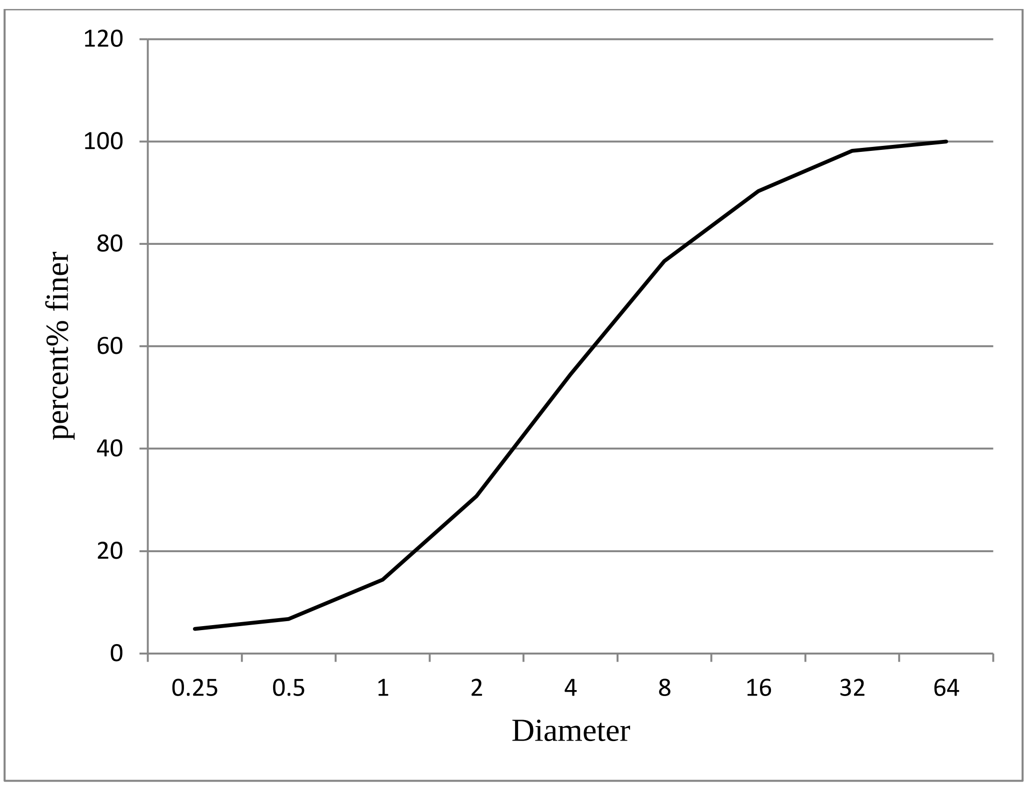


Figure (5.22) Daily sediment load out from Himeran reservoir with different value of Erodibility factor

Throughout the sensitivity analysis it is concluded that the cover factor and erodibility factor have large effect on the soil erosion from the water shed and then the sediment inflow and deposited in Himeran reservoir. Also, It should be noticed that the increase in these factors leads to a similar increase in the sediment inflow to reservoir.

After sensitivity analysis decide to study the effect of change the size distribution curve for the sediment load in the Subbasin. So the size distribution curve in figure(5.23) used as input instead of the figure(5.2) , The results were then compared in figure(5.24) , the comparison show the curve with larger percent of large particle cause the least value of sediment deposition in reservoir because of the large amount of these sediment deposited before reaching the reservoir.



Figure(5.23) test size distribution curve for sediment load

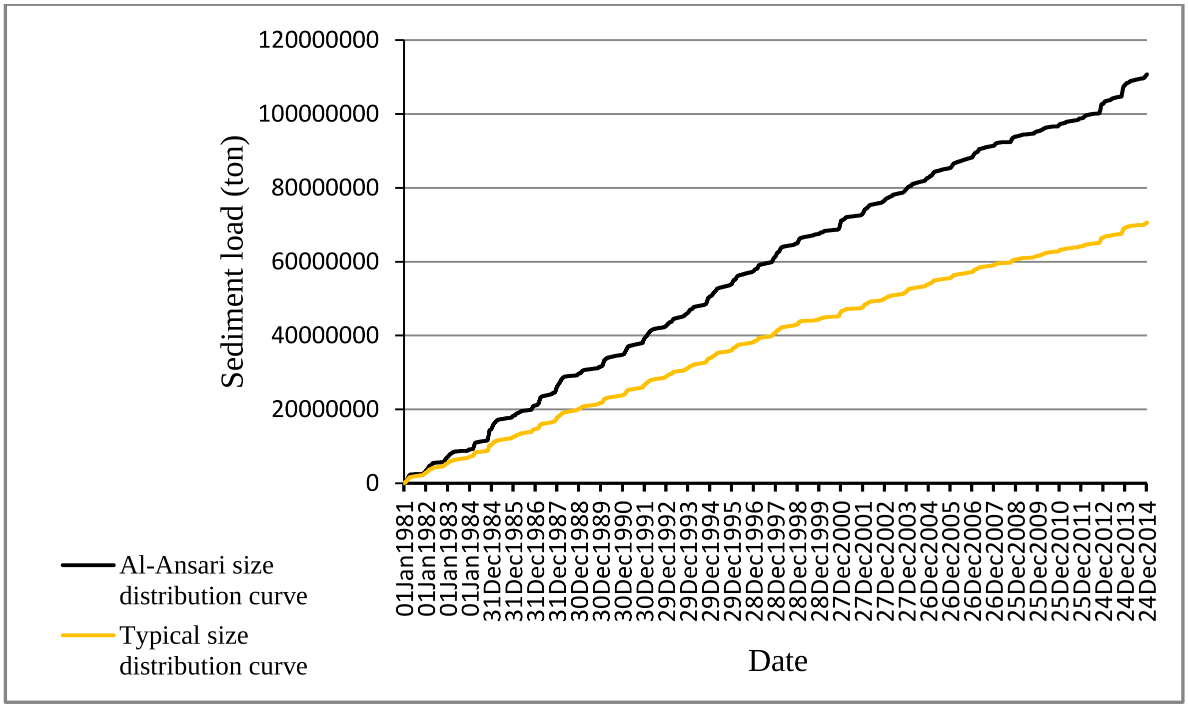


Figure (5.24) Sediment deposited in Himeran reservoir with different size distribution curve

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

The sediment phenomenon is manifold phenomenon being affected by many uncontrolled factors. Studying this phenomenon receives a great interest since it is a major problem which threatens the utilization of water control project . Since this problem exists in Himeran reservoir so the simulation for sediment entering and deposited in Himeran reservoir was done by used of HEC-HMS. Collection of data for this study from Diyala basin included the metrological data, description of the basin, geometric boundaries of Diyala river and the initial and boundary condition of Himeran reservoir. The results obtained from this simulation indicate that the average annual sediment deposited is ($3.25x10^6$ Ton) while the average annual sediment deposited volume in Himeran reservoir is 4.834 MCM. Erodibility factor and cover factor are used to make a sensitivity analysis. The sensitivity analysis prove that these two factors have an important role in determining sediment entering and deposition in Himeran reservoir.

6.2 Conclusion

Through this study the following conclusions were reached :

1- The load of sediment entering Himeran reservoir is directly affected by the precipitation depth in Diyala river basin so the largest value of sediment income to reservoir occurred in November due to the largest value of precipitation which occurred at that time.

2- The deposited sediment volume in reservoir greatly affected by the load of sediment coming to the reservoir (94% of sediment entering to the reservoir will be deposit) .

3- One hundred percent of sediment out from reservoir is a clay class. This due to the small size of clay particles which are allowed to be stuck with low velocity of water.

4- Increasing water discharge leads to increase the sediment load out from reservoir with survival value of inflow of sediment and vice versa. Sediment load out from Himeran reservoir in March 1981 is greater than the load in April 1988 although the water out flow for April 1988 (779M^3/S) is larger than (417 M^3/S) in March 1981 since the sediment entering to the reservoir in March 1981(53771 TON) was larger than the load in April 1988 (9971 TON).

5- The cover factor and erodibility factor for soil in watershed have a great effect on the results founded. The largest value of these two factors lead to an increase in erosion and sediment load entering to reservoir (the increase of cover factor with 0.2 leads to increase the sediment load entering the reservoir with 25% while the increase of erodibility factor with 0.15 causes an increase in the sediment load entering to Himeran reservoir with 27.3%).

6- The soil that has low erodibility factor is showed to be more resistant to the erosion, hence the clayey soil has large resistance to erosion than sandy soil because it has lower erodibility factor.

6.3 Recommendations

The following recommendations are suggested:

1. Geomorphological study for Diyala basin including a measured factors such as erodibility factor, cover factor and size distribution curve for sediment load for each Subbasin in Diyala river basin is recommended.
2. Developed a model to simulate sediment distribution within Himeran reservoir directed to predict the change in a bathometric chart of sediments.

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تخمين الترسبات في خزان حمرين بأستخدام HEC-HMS

اعداد

يوسف واثق أمين

المشرف | المشرف المشارك

أ.د ثاير حبيب عبدالله | أ.م.د قاسم حميد جلعوط

المستخلص

سد حمرين من السدود المهمه في العراق ويقع على مجرى نهر ديالى ، وبما ان مشكلة الرسوبيات هي من المشاكل الرئيسيه التي تؤثر على السدود و الخزانات لذلك تم عمل محاكاة للترسبات في خزان حمرين وباستخدام برنامج HEC-HMS 4.1 . عملية المحاكاة تطلبت توفر العديد من البيانات لاستخدامها كمدخلات مثال على ذلك كمية الامطار المتساقطه في حوض نهر ديالى، الخصائص الجيومورفولوجيه للحوض، المقاطع العرضيه لنهر ديالى بالاضافه الى كمية المياه المطلقه من خزان حمرين والعديد من المدخلات الاخرى. عملية المعايره للموديل تمت باستخدام البيانات الحقلية المقاسة للتصاريف في نهر ديالى، و من خلال هذه العمليه تم الوصول الى توافق جيد بين الموديل و البيانات الفعليه. عملية المحاكاة تمت للأربع و ثلاثون سنه و للفتره من 1981 الى 2014. النتائج التي تم الحصول عليها بينت ان المعدل السنوي لكمية الرسوبيات الداخلة الى البحيره يساوي($3.43\text{x}10^6$) طن ، بينما كان المعدل السنوي للكمية المترسبه يساوي ($3.25\text{x}10^6$) طن. النتائج بينت ان اعلى كمية للرسوبيات الداخلة الى البحيره حدثت في نوفمبر من العام 1984. عملية المحاكاة أوضحت ان الطين كان يشكل نسبة 49.5% من كمية الترسبات في البحيره بينما كانت نسبة الغرين40.3% في حين ان الرمل والحصى شكلا 8.9% و 1.3% على التوالي. تحليل التغيير اوضح ان النتائج المستخلصه تتأثر بعامل الغطاء النباتي في حوض نهر ديالى وعامل مقاومة التعريه لتربة الحوض.

جمهورية العراق

وزارة التعليم العـــــالي

والبحث العلمـــــي

جامـــــعة ديـــــالى

كلية الهندســــــة

تخمين الترسبات في خزان حمرين بأستخدام

HEC-HMS

رسالة

مقدمة إلى مجلس كلية الهندسة في جامعة ديالى

وهي جزء من متطلبات نيل درجة ماجستير علوم

في الهندسة المدنية

من قبل

يوسف واثق أمين

بكالوريوس هندسة مدنية، 2014

اشراف

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