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ESTIMATION OF ACCUMULATED SEDIMENT IN AL-WAND DAM RESERVOIR

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

by

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SUPERVISORS' CERTIFICATE

We certify that this thesis entitled **"ESTIMATION OF ACCUMULATED SEDIMENT IN AL-WAND DAM RESERVOIR"** was prepared by **"Ali Mohammed Sami Ali"** under our supervision in the University of Diyala in partial fulfillment of the requirements of the degree of Master of Science in Civil Engineering.

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We certify that we have read the thesis titled (**ESTIMATION OF ACCUMULATED SEDIMENT IN AL-WAND DAM RESERVOIR**) and we have examined the student (**Ali Mohammed Sami Ali**) in its contents and what is related to it, and in our opinion it is adequate as a thesis for the degree of Master of Science in Civil Engineering.

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DEDICATION

To

my parents,

my great brother, Dr. Ahmad and my brother, the martyr Qatada, who was one of the reasons behind my acceptance in the study,

my family, my wife and my children

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First and Foremost, all praise is devoted to the Almighty ALLAH (SWT), the Lord of the worlds, without His willing, I cannot have the determination to undertake this research study, and completing it to appear in its current form. Profound and sincere gratitude is expressed to my supervisor Prof. Dr Thair H. Abdullah and my co-supervisor Assist Prof. Dr. Qasim A. Aljanabi for their invaluable support and guidance throughout all the experiments and the thesis stages, which have significantly contributed to the success of this research. Also AL-Wand Dam Project Management, State, Ministry of Water Resources because of their facilities for carrying out research and Department of Water Resources, Khanaqin Division. Everybody who supported my journey to obtain the Degree of Master of Science in Civil Engineering.

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Estimation of Sedimentations for Al-Wand Dam Reservoir

By

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Co-supervised by Assist Prof. Qasim A. Aljanabi (Ph.D.)

ABSTRACT

The sedimentation process is the most serious problem in the operation and management of reservoirs. Sediments weaken the performance of reservoirs, reduce their storage capacity and disturb typical operations. It is essential, therefore, to assess the storage capacity of reservoirs regularly and follow up the sedimentation process for effective operation. In this study, the sedimentation of Al-Wand Dam Reservoir, was estimated. It is located in Diyala Governorate, north east of Iraq. Although the operation of the dam was started in 2012, there is a lack in studies related to assessing its reservoirs sedimentation. The first method, SWAT 2012 model, was used for simulating the surface runoff and the yielding of sedimentation from Al-Wand dam watershed, in Al-Wand river basin, within Iran and Iraq. Moreover, the second method GIS (Geographic Information System) applications with a 30 m DEM and soil map were used to present and analyses the sediment yielding in Al-Wand Dam Reservoir, Khanaqain. The input data to the SWAT model was based on the available data from 1979 to August 2014 in terms of precipitation, air temperature (the minimum and maximum values), relative humidity and solar, in addition to the data of stream flow which was available from 2006 to 2017. The catchment area of 3028.37 km^2 was surveyed using remote sensing techniques and satellite images which include Digital Elevation Model (DEM) maps, land cover maps and soil maps of Food and Agriculture Organization (FAO). The results showed that the average Annual Basin and maximum of surface runoff for 33-year period from

1979 to 2014 is equal to (39.02, 38.84 mm) respectively and the average Annual Basin and maximum of total sediment loading through 33-year is equal to (9131,2783 T/Km^2) respectively. As for minimum surface runoff and sediment loading equal to zero htrough the month june-septamber. In this study, the stream flow from 2006 to 2011 was used for model calibration and the 2012 to 2014 flow data was used for model validation. The performance of the model was evaluated by using a time series plots of observed and simulated value and the statistical measures of coefficient of determination (R2) equel zero and the Nash-Sutcliffe efficiency (NS) (-423675).The statistical analysis of calibration results for Al-Wand watershed don't showed satisfactory agreement between observed and simulated daily values, with an R2 value. In recent years,which is (GIS) began to be applied to the system as a means of assistance effective in handling data and inclde it in the computer data available from different maps regarding topography, soil type, land cover, and others.The work is directed to estimating sediments in a volumetric method by applying GIS applications. The second method is to estimate the sediments of the dam reservoir by using GIS applications based on the reference elevation of the dam reservoir using the hydrographic survey of digital elevation modeling maps of 2011 and the bathometric survey of 2015. This was conducted a study that included four Cases that were the closest to reality and the nearest for the design who was 50 years. This study comprised 4 km^2 of the reservoir and 215 m (a.s.l.) from levels, along with measuring the volume of the dam reservoir for these periods and finding out the differences in volume between them, to reach a sediments volume about 5,695,283 m^3 during the above periods and an annual average of about 1,423,821 m^3 per year. The operated life is expected to be 46 years in the case of repeated climatic conditions and similarity for the period studied.

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LIST OF TERMINOLOGY

TERMINOLOGY	Definitions
Arc SWAT	Arc GIS interface for Soil and Water Assessment Tool
AWDPM	AL-Wand Dam Project Management, State, Ministry of Water Resources
CFSR	Climate Forecast System Reanalysis

CN^2	Curve Number for moisture condition II
DEM	Digital Elevation Models
DSMW	FAO Digital Soil Map of the World
FAO	Food and Agriculture Organization
GIS	Geographic Information System
HEC-HMS	Hydrologic Modeling System of Hydrologic Engineering Center
HRU	Hydrologic Response Unit
LULC	Land Use and Land Cover
NRCS	National Resources Conservation Service Organization for Dams & Reservoirs, Iraqi
SCS	Soil Conservation Service
SUFI 2	Sequential Uncertainty Fitting Version2
SWAT	Soil and Water Assessment Tool
SWAT-CUP	Soil Water Assessment Tool Calibration and Uncertainty Program
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
UTM	Universal transverse Mercator
W	Wind
WGN	Weather generating data

LIST OF SYMBOLS

Symbols	Definitions	Units
a	is the degree of surface erosion	
b	is the degree of deep erosion	

c	is the coefficient featuring the sediment regime disturbed by the storage reservoir upstream of the site under consideration	
P	Precipitation	Millimeter (mm)
R	Relative humidity	No units
S	Solar	Watt/square meter (W/m^2)
T	Temperature	Celsius (˚C) and the Fahrenheit (°F)
ρ	Fluid density	g/m^3
S	is the river slope in the area of the site	

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CHAPTER ONE

INTRODUCTION

1.1 General Overview

The dam construction dates were found in the historical monuments in the Middle East civilizations such as Mesopotamia which is associated with the Euphrates and Tigris Rivers and Egypt on Nile River. Early dams were constructed to allow storage of water for irrigation as well as for human and animal consumption during dry periods. Nowadays, dams are generally created for multiple purposes, such as generating electricity, preventing flood hazards, irrigation and providing potable water. Sedimentation causes several problems in dam reservoirs such as reducing the storage capacity of reservoir and reducing the life of the dam. Sediment accumulation would raise the bed elevation of reservoir and then the loss of flood control. Accurate estimation of reservoir sedimentation is very important in dam management as it allows assessing the performance of dams and giving early indicators of its situations. The variation of methods used in measuring sediment deposits in dam reservoirs is due to the availability of techniques that can measure erosion and sediment production, in addition to the cost management factor (Issa, et al.,2013).

As physical methods have many limitations and constrains, the using of software and numerical modeling became a good alternative, and a variety of software programs were used for estimating reservoir sedimentation. The best software that suits a particular situation can be chosen based on the availability of data, the input of these programs, the amount of rainfall, slope, type of land characteristics and uses, comparison of space visuals for a certain period and finding differences among them.

Soil erosion is a continuous process of wearing away soil particles, in which they either end up in valleys or reach oceans by rivers and streams. Soil erosion is a global major issue and it may occur at a relatively unnoticed rate, however, it results in serious environmental problems (Balasubramanian, 2017).

Sediment occurs as a result of soil erosion when there is a motion of soil particles due to erosion and sedimentation. The process occurs in a sequence of three steps namely; erosion, transportation and sedimentation. The natural results of erosion, transportation and sedimentation throughout geological time are shown in Figure 1.1.

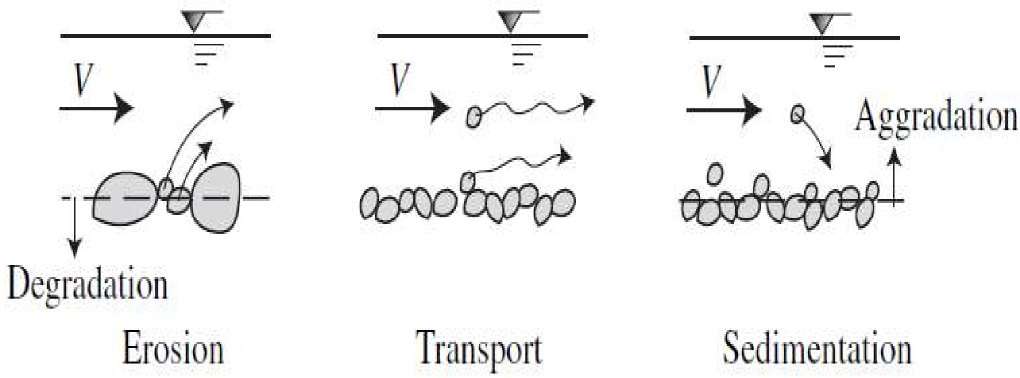

Figure 1.1 The result of the erosion, transportation, and sedimentation (Abidin, et al., 2017)

Human activities, unfortunately, accelerate the result of these three processes (i.e. erosion, transportation, and sedimentation). For example, plowing and tillage increase soil erodibility. In addition, cutting, grubbing, or burning of existing vegetation weaken the land cover. These practices would produce harmful erosion, and the productivity of fertile lands may be seriously reduced due to sediment.

Recently, the process of erosion, transportation, and sedimentation can cause critical engineering and environmental problems. The occurring of sediment in flowing channels reduces the ability to carry floods, resulting in greater floodwater and damage to adjacent properties and more frequent overflows (Plate 1.1).

The deposition of sediments increases the cost of maintaining the water ways (i.e. irrigation and drainage canals, floodways, navigation channels, and reservoirs), as well as reducing services in urban area and increasing the cost of maintenance for streets and highways. Thus, sedimentation can be considered a serious issue for water resources management and environmental protection (Julien, 2010).

Plate 1.1 Sediments of Al-Wand Dam Reservoir (19/11/2017)

Reservoir sedimentation is a continuous process due to the slow flow of the river in the dam reservoir, in which deposits reduce reservoir capacity and interfere with other reservoir functions. The flow of water from the catchment upstream of a reservoir would erode the catchment area and deposit soil into the reservoir. As sediments take up space in the reservoir, storage is reduced (Bronsvoort, 2013).

Figure 1.2 presents the typical reservoir sedimentation pattern. From the figure, the deposition usually starts with a delta formation in the upstream of the reservoir and then water flows carry sediment particles closer to the dam. However, the rate of sedimentation in reservoirs varies according to several factors such as the yielding of sediment on the watershed, the rate of sediment transport in rivers, and the deposition mode (Julien, 2010).

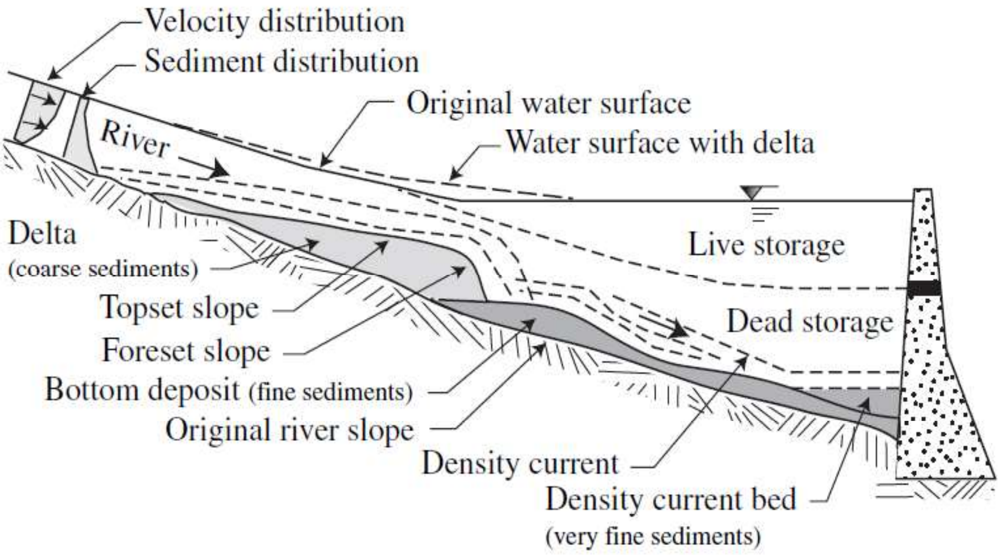

Figure 1.2 Typical reservoir sedimentation pattern (Julien, 2010)

1.2 Statement of the Problem

Because of the unavailability of observations data about the discharge of sediments from Al-Wand River

- sedimentation will cause several problem such as reduce the storage capacity of reservoir.
- The sediment accumulation will rise the bed elevation of reservoir and therefore loss flood control .

1.3 Aim of Thesis

The study aims to estimate the sedimentation in Al- wand reservoir by simulating the sedimentation processes using SWAT software. The specific objectives are:

1- To estimate the sediment in Al-wand Reservoir Watershed using the SWAT model.
2- To estimate the sediment Volume in Al-wand Reservoir using GIS application.
3- To find out the operating life of Al-Wand Dam.

1.4 limitations and Hypotheses of the Study

The SWAT can be automatically calibrated via the model Calibration and Uncertainty Program (SWAT-CUP), which was created by the aquatic research institute Eawag in Switzerland (Abbaspour et al., 2015). As a public domain program, SWAT-CUP employs a standard interface and enables various analyses of sensitivity, calibration, validation and uncertainty. The uncertainty algorithms that can be applied in this model are SUFI-2, PSO, MCMC, ParaSol and GLUE (Abbaspour et al., 2015). Furthermore, during model running, there is systematic modification of the uncertain model parameters. The output files of the model supply the necessary outputs, which are contrasted against the measured data.

- In GIS application limitations were Water level when flooding equel 217m a.s.l. and Water level at normal storage 215 m a.s.l.

1.5 Methodology

In this study, the estimation process of sedimentation in Al- wand reservoir was based on the following steps:

1. Collection of data from the study area.
2. Using SWAT as prediction model.
3. Using Arc GIS to present the results and calibration.

The flow chart of the study is presented in Figure 1.3.

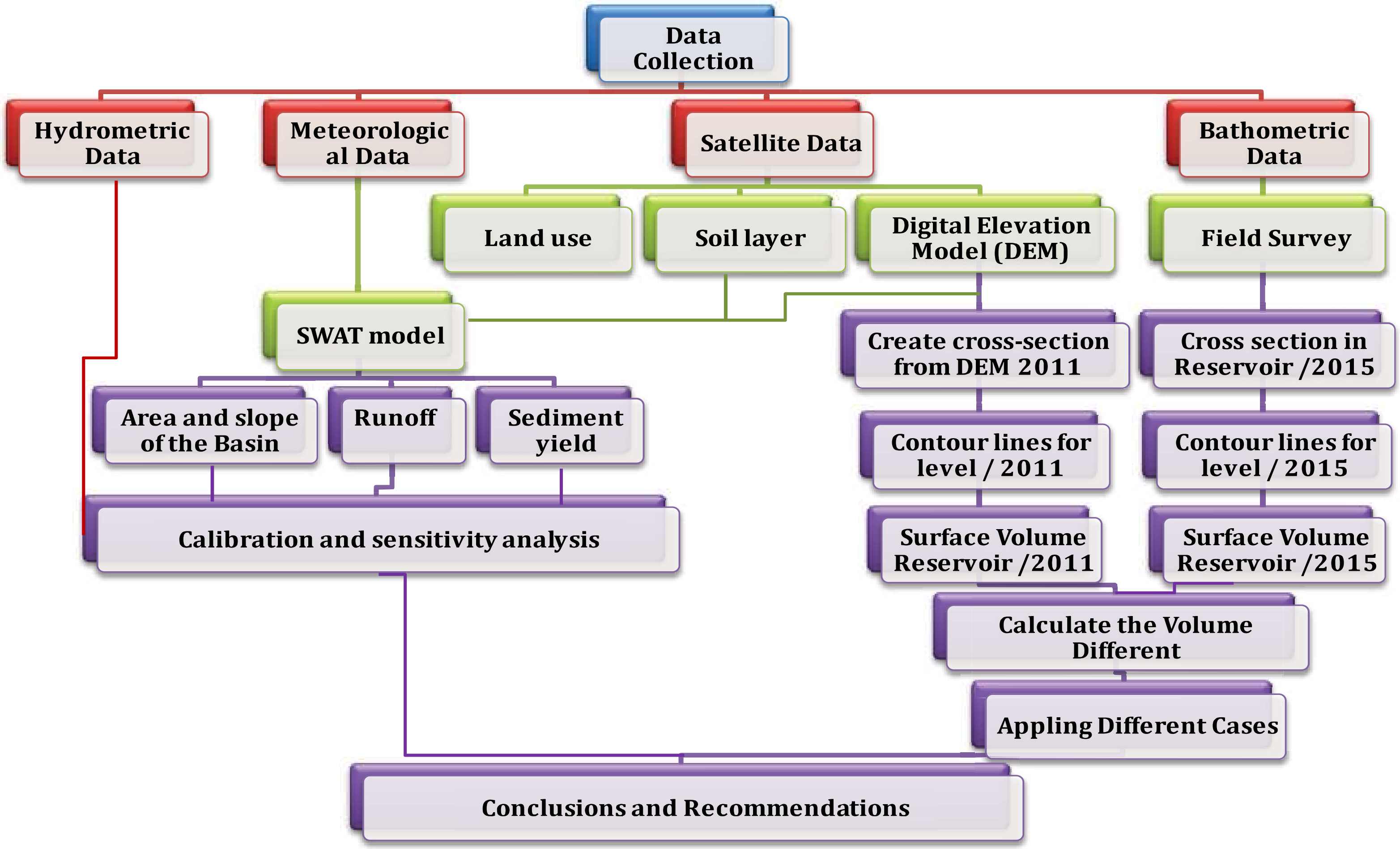

Figure 1.3 The flow chart of the study.