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Signature of Supervisors

Prof. P. K. S. Dikshit
Dept. of Civil Engineering
Indian Institute of Technology
(BHU), Varanasi

Prof. S. B. Dwivedi
Dept. of Civil Engineering
Indian Institute of Technology
(BHU), Varanasi

DECLARATION BY THE CANDIDATE

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Date:

Signature of the Student

Place: Varanasi

(Atul Kumar Rahul)

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**Prof. P. K. S. Dikshit
Dept. of Civil Engineering
Indian Institute of Technology
(BHU)**

**Prof. S. B. Dwivedi
Dept. of Civil Engineering
Indian Institute of Technology
(BHU)**

Signature of Head of Department

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Date:

Place: Varanasi

(Atul Kumar Rahul)

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ABBREVIATIONS AND SYMBOLS USED

List of Abbreviations	Description
α_s	Attenuation coefficients of suspended sediment (m^{-1})
α_s	Suspended sediment (mg)
α_w	Attenuation coefficients of viscosity of water
ΔS	Changes in soil storage (mm)
λ	Acoustic wavelength (m)
ν	Viscosity of fluids ($\text{kg}\cdot\text{m}^{-1}\cdot\text{s}^{-1}$)
ψ	Field correction coefficient
ϵ	Dissipation rate ($\text{J}/\text{kg}\cdot\text{s}$)
$\bar{S}$	Mean of observed data
$\hat{S}$	Predicted data
P_k	Production for turbulence
α_2	Volume fraction of the secondary phase
ρ_2	Density of the secondary phase (kg/m^3)
ADCP	Acoustic Doppler Current Profiler
A_{hru}	Area of HRU (m^2)
ANN	Artificial Neural Network
a_t	Transducer radius (mm)
CFD	Computational Fluid Dynamics
CFRG	Coarse fragment factor
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
E	Evapotranspiration (mm)
EI	Echo strength (dB)
FEA	Finite Element Analysis
f_T	Relaxation Frequency (Hz)
GIS	Geographic Information Systems
HEC-RAS	Hydrologic Engineering Center's River Analysis System

HRU	Hydrological Response Unit
K _c	Scale factor
K _s	Backscattering coefficient
K _t	Acoustic system transmit power (W)
LS	Topographic factor
LULC	Land Use Land Cover
LUP	Land Utilization Planning
LX _m	The transmit length
MBES	Multibeam echo sounder
MLP	Multilayer perceptron
M _s	M _s is the backscattering strength
NDVI	Normalized Difference Vegetation Index
NF	Neuro-fuzzy
NSE	Nash–Sutcliffe efficiency
P ₀	Reference pressure (Pa)
PPU	Percent prediction uncertainty
q _p	Peak runoff rate (m ³ /s)
Q _s	Surface runoff volume (m ³)
R ²	Coefficient of determination
RB	Relative acoustic backscatter
RL	Reverberation level
RUSLE	Revised Soil Erosion Equation
SCS-CN	Soil Conservation Service Curve Number
SSC	Suspended sediment concentration
SUFI-2	Using Sequential Uncertainty Fitting 2
SWAT	Soil & Water Assessment Tool
SWC	Soil and water conservation
S _y	Sediment yield (t/km ² /y)
TIN	Triangular irregular network
TSS	Total suspended solid
USGS	United States Geological Survey

USLE	Universal Soil Loss Equation
VOF	Volume of fluid
VOF	Volume of Fluid
WEPP	Water Erosion Prediction Project
WNF	Wavelet analysis and neuro-fuzzy

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PREFACE

Rivers are a perennial source of freshwater, and it is an essential need for humans and ecosystems for drinking, bathing, recreational activities, etc. The development of civilizations started on the river banks, and these continuous civilisations developed into major cities. The water demand for these cities has exponentially increased for drinking, irrigation, transportation, and many other things. Change in quantity or quality of these fresh waters affects human life severely. The uneven distribution or modification in patterns cross-sections or other geometric or hydraulic features leads to flood and drought, leading to severe impact on human life. Due to the increase in manmade/industrial activities near these cities, the nature and quantity of pollutants are increasing, leading to degradation in water quality. These degradations in the quality of water are leading to a reduction in its utility. Therefore the effective management of water of the river is essential and a big challenge for engineers.

The river Ganga is India's most prominent and holy river and has the largest basin of 10,00,000 km². It also acts as a lifeline for major cities of north India like; Haridwar, Kanpur, Prayagraj, Varanasi and Patna. The great northern plain of India has formed in the basin of the river Ganga. Varanasi city is located on the bank of river Ganga and known as the pilgrimage city of India. Varanasi is having a population of 1.2 Million and having 80 bathing Ghats. Sediment transport is a natural process of the river, and it is getting affected due to anthropogenic activities and the construction of hydraulic structures/ bridges. Change in this sediment transport process, the morphology of Ganga River and its basin characteristics are changing and leading to frequent floods.

Further, due to urbanisation and human activities, different waste materials get

generated due to sewage, solid wastes and industrial effluents. Mixing of these pollutants with water of river becomes the reason for the pollution of river water. Due to these pollutions, significant degradation of the quality of water of river Ganga is taking place. Further, causing strains on the filtration process, understanding both aspects, i.e. sediment transport process and pollutant dispersion process, is essential in terms of quality and quantity of water resource management. The present study focuses on these two aspects for the river Ganga nearby Varanasi City.

The numerical modelling and physical modelling aspects have been investigated to understand sediment transport and pollutant transport behaviour. For modelling of sediment yield of the basin near Varanasi process of Soil and Water Assessment Tool (SWAT) analysis is used in this study. Land Use Land Cover (LULC) map, soil map, hydrological data, and metrological data have prepared using Digital Elevation Model (DEM) for SWAT analysis. ArcSWAT software package had used for the SWAT analysis. Calibration and validation of the data have done with the help of Sequential Uncertainty Fitting version 2 (SUFI-2). For physical measurement of the sediment concentration and its impact over bed cross-section, the Acoustic Doppler Current Profiler (ADCP) instrument was used for the stretch considered for the study. ADCP data gives bed cross-section and backscattering data for the determination of sediment concentration. For getting sediment concentration, backscattering data needs to be calibrated by the direct measurement of sediment concentration. Modelling the sediment transport process of river Ganga near Varanasi was done by the Hydrological Engineering Centre – River Analysis System (HEC-RAS) software package. RAS-Map prepared by DEM, hydrological data and metrological data was used as input data. Bed cross-section and sediment concentration were obtained as

output. It is observed that the sediment yield of the watershed has been increased in recent time. The bed profile and sediment transport behaviour are changed at some of the cross-section.

For modelling pollutant transport behaviour, the ANSYS software package was used. Modelling the stretch of river Ganga near Varanasi with Assi Nallah as a major pollutant source was considered for understanding pollutant transport dynamics. Geometric characteristics, flow characteristics of river Ganga and Assi Nallah was used as input data. The flow pattern was obtained as output. The physical modelling is used to validate the result of computational model. Physical modelling was done with the help of an S-bend channel, and the flow pattern of the pollutant was obtained. Flow pattern indicates the extent of pollutant flow in the river. Therefore, it can help in the management of pollutant discharge in the river. The present study observed that sediment transport behavior significantly depends upon basin characteristics, flow discharge, and morphology of the river. A total of fifteen cross-sections have been considered and found two cross-sections having excessive depositions. It has arrived that the pollutants are flowing in the concave side of the river, and the existent concentration of pollutants are up to 2 km. The concentration of pollutants after that is less than the upstream section.