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SUSTAINABLE SOLUTIONS FOR A GREENER FUTURE – A CASE STUDY OF MUSI RIVER AND HYDERABAD CITY AREA.

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ABSTRACT
The city of Hyderabad disposes a very large quantity of untreated domestic sewage into the dry bed of the Musi River. Regrettably, the Musi River expressions severe pollution due to the discharge of untreated sewage and industrial waste. This has led to a decline of water quality, impacting aquatic life, and posing health risks for people residing nearby. In the present paper the study is focused on identifying drains of the Musi River within the Hyderabad drainage basin. study flood flows into the Musi River with respect to rainfall, study the drainage waste entering into the Musi River per day from the Hyderabad drainage basin and design separate side drains to carry sewage without polluting the river. The Identification of sewage drains and Runoff into Musi River are determined using the RS&GIS Software. The Determination of Sewage based on population and the Design of Size of sewage drain is estimated using SCS Curve Number Model.
Keywords: Musi river, permeable layers, RS&GIS, Runoff & rainfall, Infiltration and Floods.

1. Introduction
The study area, Musi River catchment area located in Hyderabad region starting from Narsing to Ghatkesar. It originates in the Anantha Giri Hills, near Vikarabad. It generally flows towards the east, turning south at Chittaloor. It flows into the Krishna River at Vadapally near Miryalaguda in Nalgonda district. Stretch of Musi River within Hyderabad region is 61.5Km covering an area of 1157 Sq.km. Latitude 17’21’59.99” N Longitude 78’27’59.99’’E. location as shown in figure1.

Geographical Features:
The soil in the catchment area is “Chromic Luvisols” soil with is categorized as “A” consist of very deep moderately well drained, dark red, clayey profile.

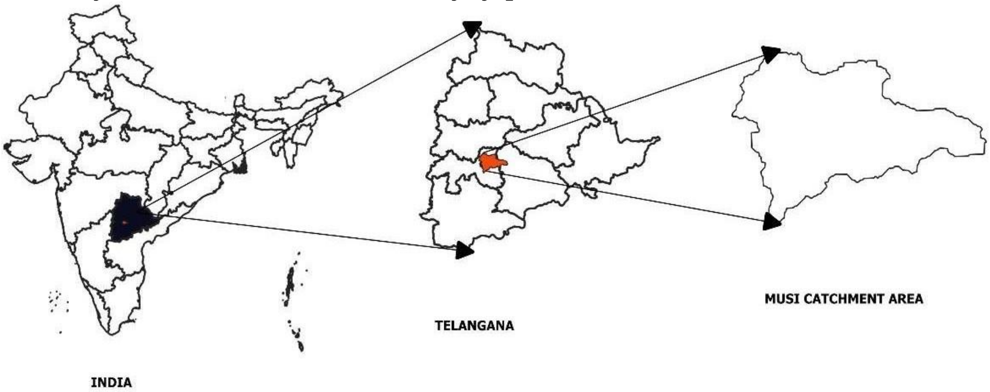

Figure 1. Location map of Musi River

2. Methodology
The methodology used to fulfil Identification of sewage drains and Calculation of Runoff into Musi River, Determination of Sewage based on population and Design of sewer drain the following steps are used. Flow Chart of the design of side channels as shown in figure 2.

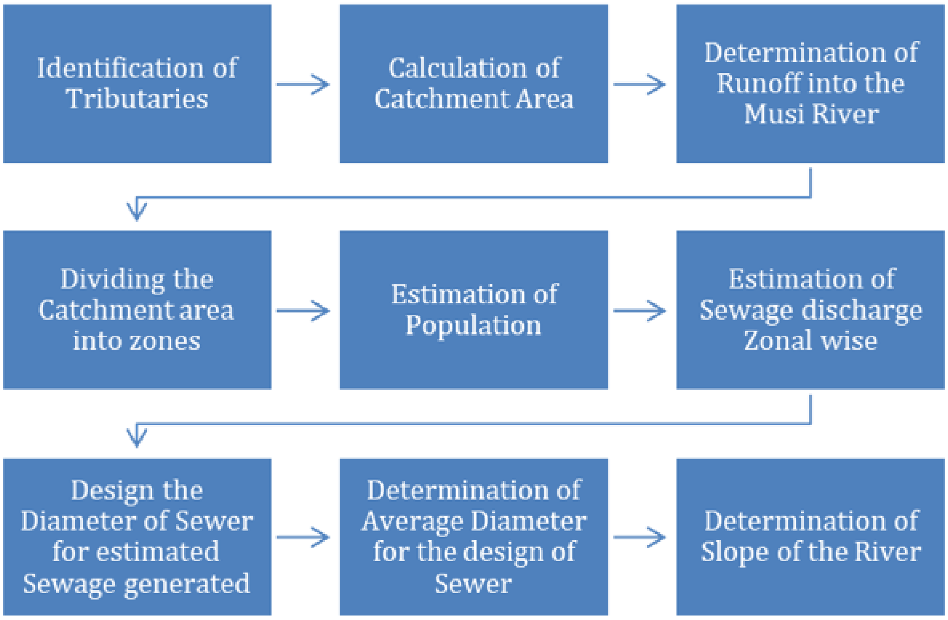

Figure 2. Methodology flow chart

2.1 Identification of sewage drains flowing into the Musi River.

The integration of QGIS software with spatial data analysis techniques offers a powerful approach for identifying and characterizing sewage drains flowing into the Musi River. This study contributes to a deeper understanding of the complex interactions between urban infrastructure, environmental degradation, and water quality, while also providing valuable insights for policymakers, researchers, and stakeholders involved in the restoration and conservation of the Musi River watershed as shown in figure 3.

Step 1: Firstly, the catchment area of the Musi River is identified and separated from the overall watershed dem file. Step 2: By overlaying the rivers map downloaded from watersheds website and extracting the rivers is done. The Musi River flowing through the Hyderabad region is separated and aligned with the catchment of the Hyderabad basin.Step 3: From the extracted river map of Musi River, the major outlets where the maximum sewage discharge occurs are identified. Step 4: Starting and ending points of the major drains are identified. Step 5: Length and area of the catchment and each major drain are also identified.

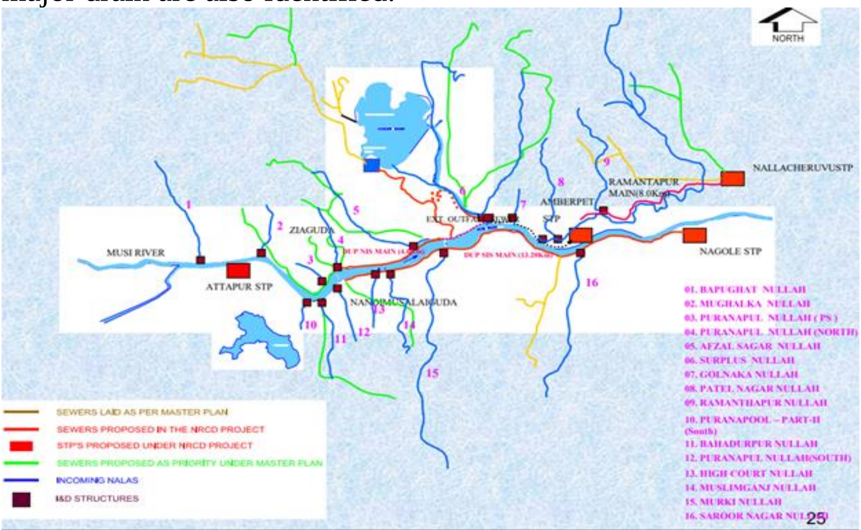

Figure 3. Musi River Stream map

2.2 Estimation of Sewage based on population

For the calculation of Sewage, firstly we need to determine the population of the Hyderabad city region, which is covered by the Musi River catchment area. Calculate the total population of the given

area, one must know the population density of the area and the area of the required place where the population is to be determined. To determine the population along the Musi River catchment area, the total area is divided into smaller zones. Each zone is divided based on the major tributaries discharging sewage into the Musi River and area of each zone is calculated using QGIS software. After determining the area of each zone and population density around the Hyderabad city, it will be easy to find out the population at each zone.
By using the formula, Population Density=Population/Area
We can derive population, Population=Population Density*Area
Based on the above population and per capita sewage generated every day, Sewage generation per day can be estimated. This estimation will be further helpful in the design of side channels for the river.
By using the formula,
Sewage=Per capita sewage*Population in MLD

2.3 Calculation of Runoff into Musi River

The methodology followed to estimate runoff using SCS Curve number model by using the land use/ land cover map, soil map of Musi River catchment area. Rainfall data around the catchment area is used to estimation of runoff. Runoff was estimated with the aid of hydrological model using USDA (United State Department for Agriculture) methodology for estimation of surface runoff using SCS (Soil Conservation Service) curve number model.
SCS Curve Number Model:
The curve number method (Soil Conservation Services, SCS, 1972) also known as the hydrologic soil cover complex method, is a versatile and widely used procedure for runoff estimation. This method includes several important properties of the watershed namely soil permeability, land use and antecedent soil water conditions which are taken into consideration. To estimate the curve number, depth of runoff the land use/land cover and hydrological soil group map.
The Curve Number values for AMC-I and AMC-II were obtained from AMC-II (Chow et al. 1988) [3] by the method of conservation. Runoff curve numbers (AMC II) for hydrologic soil cover complex are shown in Table 1.
Table 1: Hydrological Soil Group Classification [Ref. 8]

Soil Group	Description	Infiltration rate mm/hr.
A	Soils in this group have a low runoff potential (high infiltration rates) even when thoroughly wetted. They consist of deep well to excessively well-drained sands or gravels. These soils havea high rate of water transmission.	7.62 – 11.43
B	Soils in this group have moderate infiltration rates when thoroughly wetted and consists chiefly of moderately deep to deep, well-drained to moderately well-drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.	3.81 – 7.62
C	Soils have slow infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes the downward movement of water, or soils with moderately fine-to finetexture. These soils have a slow rate of water transmission.	1.27 – 3.81
D	Soils have a high runoff potential (very slow infiltration rates) when thoroughly wetted. These soils consist chiefly of clay soils with high swelling potential, soils with a permanent high-water table, soils with a clay layer near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.	0 – 1.27

2.4 Design of sewer

The design of a circular side channel for sewage generated for the Musi River involves careful consideration of hydraulic principles, environmental impact, and structural integrity. A circular side channel is a conduit or channel constructed alongside the main river to carry sewage and wastewater away from the river itself, preventing direct discharge and pollution. The design process begins with an assessment of the volume and flow rate of sewage generated by the surrounding population, determined through calculations based on population density and per capita sewage generation rates. The circular shape of the channel helps optimize flow dynamics and minimize sediment deposition and clogging.

3. Results and calculations

3.1 Estimation of surface features

The surface features of the catchment area are classified based on the land use / land cover technique with the help of RS &GIS Software. For this study the satellite images are taken for the years 2013,2018 and 2022.only three surface features are classified that are useful for the estimation of surface runoff such as Vegetation, built up & Water bodies presented in table 2. Land use &Land cover maps shown in figure 3

Estimation of surface features of the years 2013,2018 and 2022:

Table 2. Different Surface features of the catchment area

Land classification of catchment 2013			
Land classification	Area(km^2)	Area%	Curve Number
Vegetation	390.6	33.75972	49
Built up	630.68	54.50994	89
Water bodies	135.72	11.73034	100
Total	1157		
Land classification of catchment 2018			
Vegetation	179.27	15.49438	49
Built up	806.08	69.66984	89
Water bodies	171.65	14.83578	100
Total	1157		
Land classification of catchment 2022			
Vegetation	125.94	10.88505	49
Built up	929.56	80.34226	89
Water bodies	101.5	8.772688	100
Total	1157		

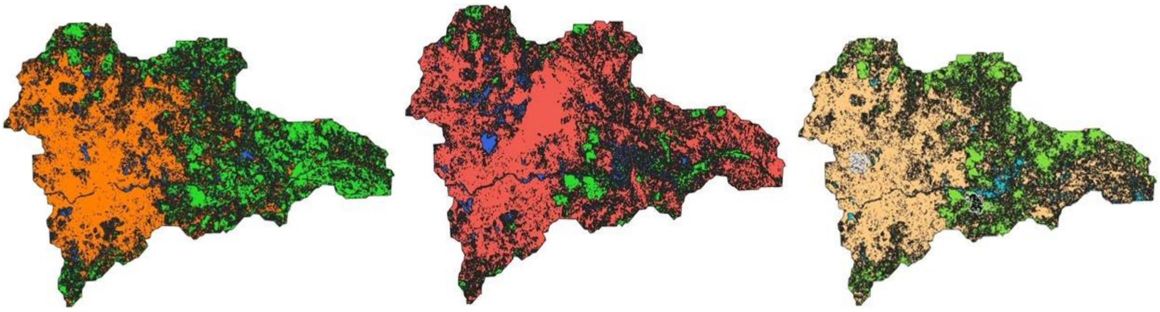

Figure.4. Land use Landcover Maps of the years 2013,2018 and 2022

3.2 Runoff calculation

The runoff of the catchment is calculated based on the surface features and the rain fall intensity at the catchment area of the hydra bad city. Table 3 Presents Runoff estimation details.

Table 3: Runoff Calculation 2013

Year	Rainfall	Land classification	CN	S	Runoff
2013	1018.32	Vegetation	49	264.3673	757.909
	1018.32	Built up	89	31.39326	981.5926
	1018.32	Water bodies	100	0	1018.32
2018	570.281	Vegetation	49	264.3673	342.4394
	570.281	Built up	89	31.39326	534.2644
	570.281	Water bodies	100	0	570.281
2022	960.62	Vegetation	49	264.3673	703.0066
	960.62	Built up	89	31.39326	923.9479
	960.62	Water bodies	100	0	960.62

Land use/Land cover is a very important parameter for identification of Areas. Fig (4), shows the changing of area over years from 2013,2018 and 2022. In the year 2013 the area used for vegetation, built up and water bodies is 390.6sq.km, 630.68 sq.km and 135.72sq.km respectively. In the year of 2018 the area used for vegetation, built up and water bodies is 179.27sq.km, 806.08sq.km and 171.65sq.km of respectively. In the year of 2022 the area used for vegetation, built up and water bodies is 125.94sq.km,929.56sq.km and 101.5sq.km respectively. The percentage of area of Built-up area over years during 2013 the percentage of area is 54.51% in the year 2018 the percentage of area increases to 70% and in the year 2022 the percentage of area increases to 80.34%.

The Built-up area increases frequently over years due to this increase of area the run off also increases. To avoid the problems the side channels are designed based on the sewage quantity and population over the area

3.3 Estimation of Sewage discharge into Musi River

The Population density of Hyderabad region is 18480 per sq. km [Ref. 10]. Total population = Area x Population density. Sewage per capita = 121 liters [Ref. 11]. Total sewage quantity = Area x Population Density x Sewage per capita in liters. Sewage quantity in MLD = Sewage quantity in liters x 10^{-6}

Tabll.4. Details of sewage quantity from individual detrains

Locations (ID)	Area km^2	Population	Sewage ltr.	Sewage MLM
1	139.750	2582580	312492180	312.492
2	251.980	4656590	563447390	563.447
3	180.250	3331020	403053420	403.053
4	215.470	2981886	481808206	481.808
5	65.366	1207964	146163644	146.164
6	214.360	3961373	479326133	479.326
7	143.620	2654098	321145858	321.146

The Population density of Hyderabad region is 18480 per sq. km [Ref. 10]. Total population = Area x Population density. Sewage per capita = 121 liters [Ref. 11]. Total sewage quantity = Area x Population Density x Sewage per capita in liters. Sewage quantity in MLD = Sewage quantity in liters x 10-6

3.4 Design of Side channels

For the design of side channels, circular sections are convenient to allow the sewage to flow freely and construction of circular channel is also economical.

The material of the drain is concrete and Shape is Circular. The Velocity conditions for circular sewer: Minimum velocity = 0.45 m/sec and Maximum velocity = 0.9 m/secNo silt or No scouring velocity = 0.9 m/sec [Ref. 12]. In order to design the sewer, first the area of the sewer is to determine from the formula given,

Q=A×V

Where, Q = Sewage discharge,

A = Area of the sewer,

V = Velocity Consider,

V = No silt or No scouring Velocity i.e., 0.9 m/sec.

Q is estimated according to each zone.

Table 5. Design Parameters of Side Channels

Zone	Estimated Discharge (Q) (in m^3/sec)	Area of the channel (m^2)	Diameter (m) (For circular)
Zone 1	3.616	4.017	2.26
Zone 2	6.52	7.244	3.03
Zone 3	4.665	5.183	2.568
Zone 4	5.576	6.195	2.808
Zone 5	1.691	1.878	1.54
Zone 6	5.54	6.155	2.79
Zone 7	3.716	4.12	2.19

Zone 1, 2, 3, 4 are on the one side of the river basin and the Zone 5, 6 7 are on the other side. In this case, two side channels are to be designed for both the sides of the river. Average diameter of the side channel 1 and 2 are

$$Avg.Dia = \frac{2.26 + 3.03 + 2.568 + 2.808}{4}$$

$$= 2.7\ m = 3\text{m}$$

$$Avg.Dia = \frac{1.54 + 2.19 + 2.79}{4}$$

$$= 2.12\ m = 2.4\text{m}$$

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3.5 Determination of Slope

Slope plays a significant role in the design of channels. To allow the sewage or water to flow with gravity, it is necessary to maintain the slope accordingly. As the river flows with the gravity, it is considerable to maintain the slope of the river for the design of sewers. Firstly, to calculate slope of the river basin, the elevations of the river at every 5 kms of length are determined and by using the slope formula, slope is known.

Slope formula, $\text{Slope} = \frac{\text{Elevation}}{\text{Horizontal Distance}}$

Table 6 Slope Calculation

Sl. No	Horizontal Distance (km)	Elevation (m) from MSL	Slope in percentage	Slope in Gradient
1	0	534	0	0
2	5	522	0.24	0.0024
3	10	513	0.18	0.001
4	15	512	0.02	0.0002
5	20	494	0.36	0.0036
6	25	483	0.22	0.0022
7	30	475	0.16	0.0016
8	35	473	0.04	0.0004
9	40	468	0.1	0.001

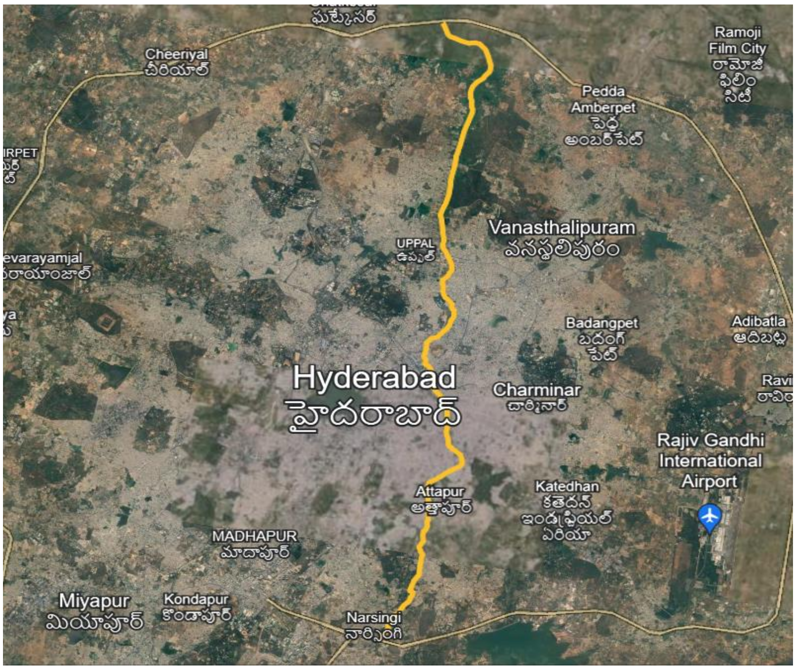

Fig.4 Showing the flow of Musi River through Hyderabad

IV. Conclusion

The average sewage generated per capita is found to be 121 liters per day, using that sewage generated for the complete population of Hyderabad region is 2700MLD per day. Hyderabad catchment is divided into different zones based on the major drains from which the maximum amount of sewage is disposed. Design of side drain for major discharge points is done and the design parameters are as follows: For side drain 1, the average dia. of channel 1= 3m and For side drain 2, the average dia. of channel 2 = 2.4m.By comparing the rainfall-runoff trends of the years 2013, 2018 and 2022, it is observed that the impermeable layers percentage has increased about 17% in 2018 and 28% in

2022.With the increase in the built-up area percentage and no infiltration, runoff increased.. By implementing strategically placed side drains along the Musi River, we aim to enhance the overall drainage system's efficiency and resilience. This project not only addresses immediate concerns related to flooding but also contributes to the long-term sustainability and development of the region.

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