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Study of Sustainable Sanitation System for Yadgir City using GIS and Remote Sensing

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Abstract - *Water is the basic element of social and economic infrastructure and is essential for healthy society and sustainable development.*

The natural resources like river, lake and ponds are polluted due to the discharge of sewage water into the sources without proper planning.

Due to the contamination of the sources by sewage leads to surface water pollution, ground water pollution resulting in serious health hazards, breakup of waterborne diseases and in many instances the rivers getting fully flooded with sewage flow.

The priority of the sanitation infrastructure system is always in the last of all the development activity due to the financial and power constraints, hence this live case study is undertaken to design a technically and financially self sustainable ecosanitation infrastructure system for Yadgir city.

***Key Words*: Healthy society, Sewage water, Pollution, health hazards, Infrastructure, Ecosanitation etc**.

1. INTRODUCTION

Sustainable sanitation recognizes that in order to be sustainable, a sanitation approach must be socially acceptable and economically viable.

In this way, sustainable sanitation is a loop-based approach that differs fundamentally from the current linear concepts of wastewater management as shown in fig 1.a, and that does not only recognize technology, but also social, environmental and economic aspects.

Sustainable sanitation is an approach that considers sanitation holistically and it recognizes that human excreta and wastewater are not waste product, but a valuable resource.

This view is based on the fact that wastewater and excreta contain significant amount of energy, plant nutrients and also water that can be recycled and reused, thus protecting natural resources.

Water and Sanitation is one of the primary drivers of public health, this means that once we can secure access to clean water and to adequate sanitation facilities for all people, irrespective of the difference in their living conditions, a huge battle against all kinds of diseases will be won. These words, lent sanitation and health.

This implies the following criteria

- Health and Hygiene
- Environmental and Natural Resources
- Technology and Operation
- Financial and economic issues

The view of general system of sustainable sanitation system is shown in Fig,1.1.b. it is a simplified and idealized technique for use of the treated water and nutrients present in the treated effluent sludge.

It improves the yield of crop as well as revenue generation and the system focuses on the treated wastewater, the waste is not a waste, it's a important biological resources.

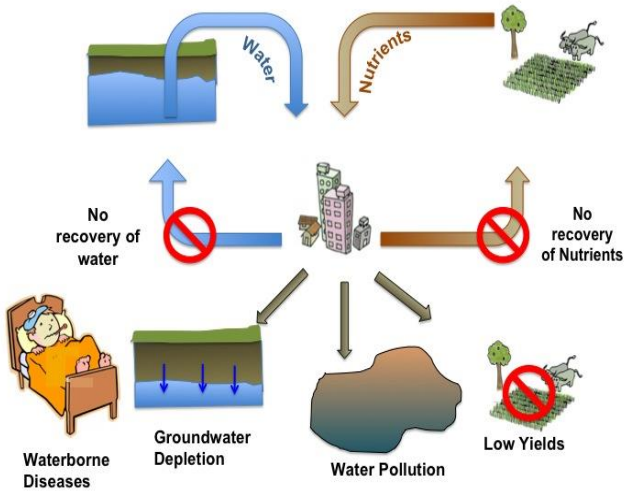
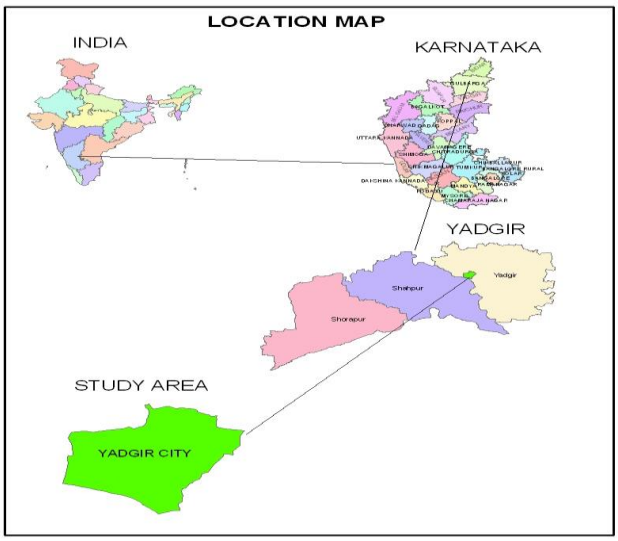


Fig 1.a. Sustainable Sanitation System

1.1 Study area

Yadgir is a city and the administrative headquarters of Yadgir district in the state of Karnataka, and the town covers an area of 5.6 square kilometers (2.2 sq mi), the Bhima River flows through Yadgir city, and it has an average elevation of 389m above mean sea level (MSL).

The city municipal council jurisdiction extends up to an area of 14.95 sq.km, population as per 2011 census was 74,294, the city shown in map 1.1.a



Map.1.1.a. Location of Yadgir city map

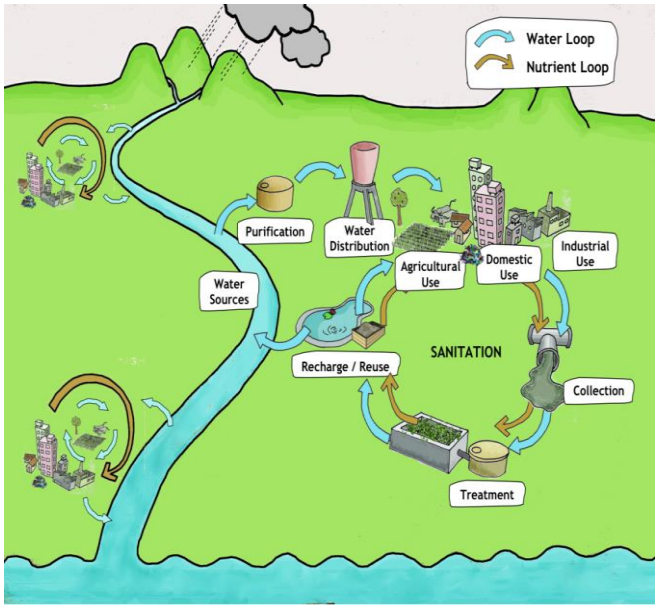


Fig.1.1.b. General system of Sustainable Sanitation System

1.2 Catchment area of Doddanala tributary

Catchment area is a geo-hydrological unit of all land and water within the confines of drainage divide which contributes runoff to a common point.

The Doddanala tributary catchment area is covered by 40,692 hectares (406.92 km^2), which is a basin shaped area of land, bounded by natural features such as hills from which surface and sub surface water flows into streams, river and wetlands.

The system of streams which transport water, sediment and other material from a catchment is called a drainage network. No catchment is exactly like another.

Each has a different size, shape, drainage pattern and features that are determined by natural processes, particularly geology and climate as show in Fig 1.2.a.

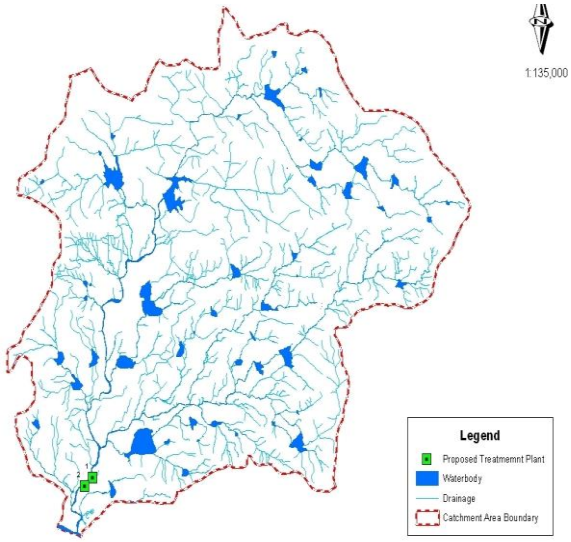


Fig.1.2.a. Catchment area of Doddanala tributary

2. OBJECTIVES

a. To evaluate the sewage collection system by gravity flow.
b. To evaluate providing treated effluent for agriculture purpose by using GIS and Remote sensing techniques for developing a sustainable sanitary infrastructure.
c. To make a detail analysis of cost benefit for self sustainability of the treatment plant maintenance.

3. MATERIALS AND METHODOLOGY

In the present study, the toposheet in fig. no III.1 and contour line in fig.no III.2. show the details of the boundaries of the catchment area and contours of Doddanala's tributary by using the GIS software.

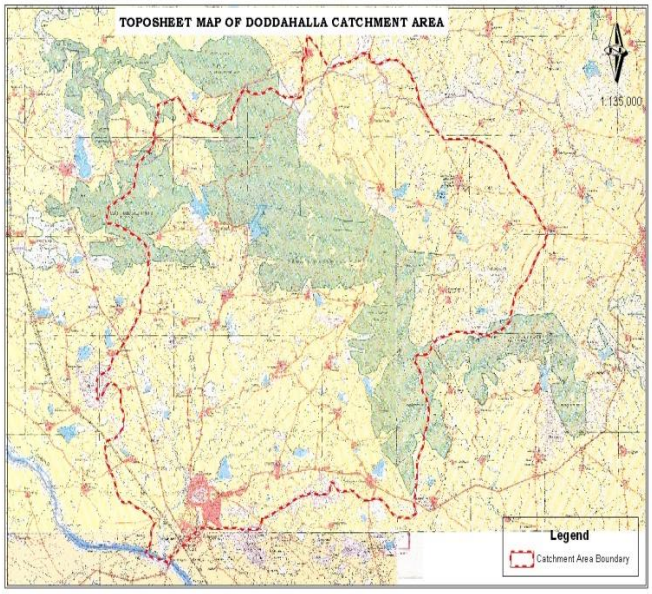


Fig.III.1 Toposheet of Doddanala tributary Catchment Area

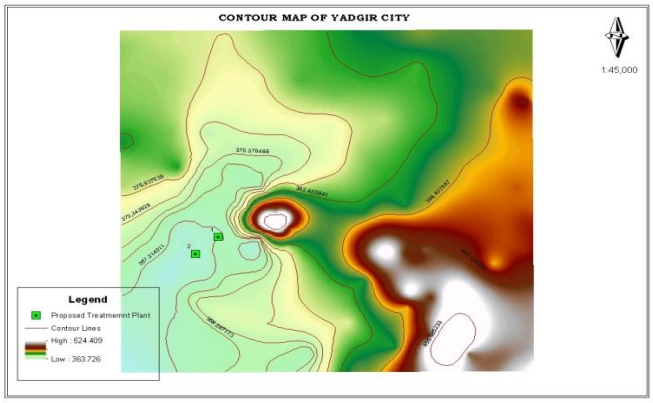


Fig.III.2 Contour map of Yadgir city

3.1 Sampling

The collection of wastewater samples may seem a relatively simple task and the collection of a representative sample becomes much more complex.

In the case study, collection of samples carried out once in a week.

3.2 Sewage Treatment Plant

Stabilization ponds are suggested for the treatment of sewage as it is more suitable in tropical climate with high efficiency in removal of BOD, Total solids and nematodes.

It has been internationally recognized that the effluent of the stabilization ponds are more suitable for agriculture as it removes all the nematodes and some more harmful activities present in it, effectively as compete any other treatment methods. It is also very economical and does not consume any energy in the process, conventional single treatment unit is avoided and provided with two smaller treatment plants unit to unable the collection of city sewage by the gravity flow.

4. RESULT AND DISCUSSIONS

Table no IV.1 Population of Yadgir city as per census department

S. No.	Zones and Ward number	Population (2011)
01	Zone I population(ward no 01-24)	53,566
02	ZoneII population(ward no 25-31)	20,728
	Population as per Census department	74,294

4.1 Population Forecasting Methods

4.1.a. Arithmetic increase method

This method is based upon the assumption that, the population increase at a constant rate, i.e. the rate of change of population with time (ie. dp/dt) is constant. $P_n = [P_o + nX]$

Table.4.1.a. Population projection of Arithmetic method

Sl no	Population Projection of Arithmetic Method	
	Year	Population Forecasted
01	2011	74,294
02	2017	82,164
03	2047	1,15,889

4.1.b. Geometric increase method

In this method, the per decade percentage increase or percentage growth rate (r) is assumed to be constant, and the increase is compounded over the existing population every decade. $P_n = P_o[1+(r/100)]^n$,

Geometric average $= \sqrt{r1 * r2 * r3..rt}$

Table.4.1.b. Population projection of Geometric increase method

Sl no	Population Projection of Geometric Increase Method	
	Year	Population Forecasted
01	2011	74,294
02	2017	85,874
03	2047	1,59,768

4.1.c. Incremental Increase Method

In this method, the per decade growth rate is not assumed to be constant as in the arithmetic or geometric progression methods, but in progressively increasing or decreasing, depending upon whether the average of the incremental increases (increment over the increase) in the past data is positive or negative.

$P_n = P_o + nx + [\frac{n(n+1)}{2}]\ y$

Table.4.1.c. Population projection of incremental increase method

Sl no	Population Projection Incremental increase Method	
	Year	Population Forecasted
01	2011	74,294
02	2017	81,057
03	2047	1,11,039

Geometric increase method is adopted because Yadgir is under developing city, recently it became the district due to this many people migrate from nearby villages. Also population is bound to increase for coming days.

Table.4.2. Projected Population and Sewage Generation in Sewerage Zones

Zones of city	Projected Population	Quantity of Sewage Generation (MLD)	Quantity of Sewage Generation (MLD)	Treatment plant location
	2047	2047	SAY	RL in m
Zone I	1,29,473	13.98	14	366
Zone II	63,573	6.86	7	367

4.2. Doddanala tributary discharge and Contamination

The volume of the discharge will be determined by factors such as rainfall, climate, vegetation, soil type, drainage basin relief and the activities of man.

In this case study it is observed that the tributary is contaminated with 83% of sewage water as shown in fig no, during 8 months of flow as shown in table no.

It is therefore seen that the major part of the flow in Doddanala tributary constitute of sewage flow contaminating the river Bhima.

This kind of scenario is seen all over the world with rapid urbanization and large migration of rural population to the city.

Hence it is envitable to develop a financially and technically self sustainable sanitary infrastructure to protect the precious water.

The calculated Doddanala's peak discharge is 913.686 m^3/sec and cross section required for peak discharge is 155.124 m^2, and the width of Nala required for peak discharge is 32.52 m.

Table no 4.2. Present scenario of Doddanala tributary from October to May

Month	Runoff water discharge (m^3/month)	Sewage water discharge (mL)
Jan	84.59	651
Feb	66.88	588
Mar	37.21	651
Apr	16.48	630
May	13.19	651
Oct	390.91	651
Nov	306.13	630
Dec	117.74	651
	1033.12	**5103**

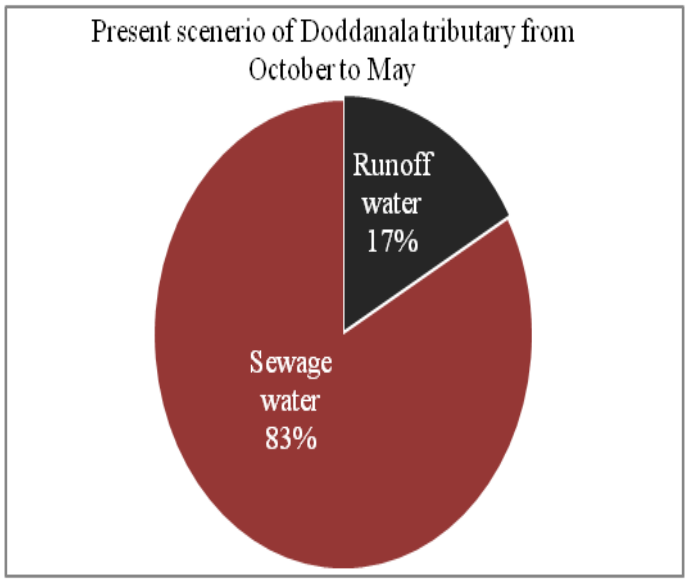


Chart no 4.2 Present scenario of Doddanala tributary

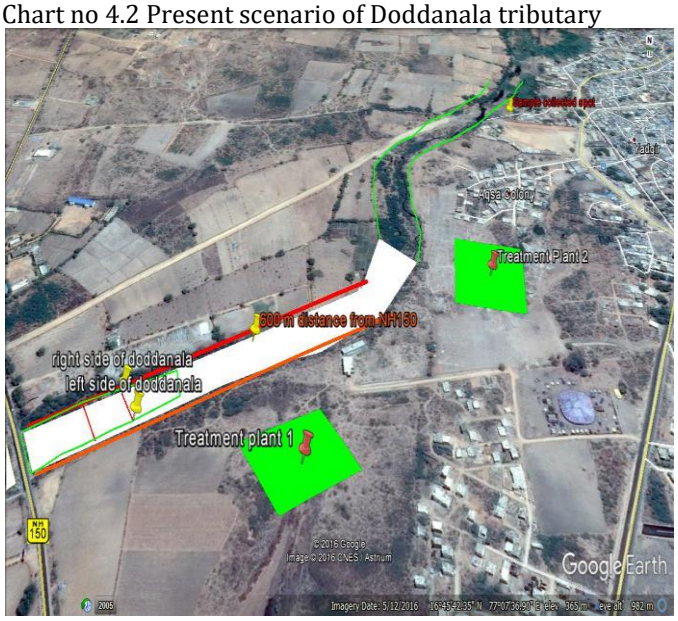


Fig 4.2: Doddanala view in Google earth

4.3 Storage pond for conserving of treated effluent

The storage tanks volume is designed for initial output of effluent for the design period of 15 years i.e 2032 having two storage tanks for 14mld, a provision is also made for providing one more storage tank of 7 mld for design period of 30 years.

The RL of pond is kept in the 386 m, and distance from treatment plants is 2KM, as per the analysis and study of the topomaps, revenue maps, and RS data with analysis made using GIS, the average RL of the agriculture field is 378 m hence gravity flow of the effluent to the field to ensure that the treated water is providing to irrigation purposes.

Diameter of the two proposed storage pond to conserve treated effluent is 122 m and the effective depth is 6 m with free board of 0.3 m extra.

4.4 Requirement of treated effluent for irrigation purposes

The following crops are sown in the Yadgir such as bajra, toor, sugarcane, groundnut, sunflower, sesame, castor bean, black gram, jowar, wheat, cotton, ragi, bengal gram, and linsed are some of the major crops grown.

In this case study, the groundnut and cotton which are cash crops can be grown in the available soil conditions giving high returns.

The requirement of water and net area that can be irrigated by the available treated effluent from the treatment plants is shown in the following table no.4.4

Table:4.4. Requirement of treated water for irrigation purposes

Crops	Requirement of water in (mm)	Crops period (days)	Net area of land irrigated	Required water for 1 acre of land in MLD
Ground nut	500-550	105 2 crops / year	122 acre/two season	0.23

The groundnut can be grown in 122 acres per two season of irrigated land.
The crop rotation can be made by this above mentioned crop.

4.5 Revenue Generation from Wastewater Treatment Plants

30 years plan period is considered and the amount of input sewage to the sewage treatment plant and consequently, the amount of productive wastewater is increasing, the incomes of the plan are determined and the general results are outlined in cost-benefit analysis (CBA). We have expressed and brought this time factor with the calculation of a period and income return in analysis. This is the very time that should be spent for the return of obtained incomes of a change in its costs.

Sl no	Irrigation land (acres/two season)	Treated effluent provided (per m^3/two season)	Cost per cubic meter (rupees)	Cost (rupees)	Total amount charged (rupees)
01	1	460	12	5520	
02	122	56,120	12	6,73,440	6,73,440
03	16,836 m^3 (30 % of sludge from treated effluent)	16,836	12	2,02,032	2,02,032
04	Subscription fee 1500 rupees per year (1500 x 61 acres)			91,500	91,500
				Total amount	9,66,972

Note : One acre of land requires 0.23mL of treated effluent. So the duration of 245days (including two seasonal crops) 122 acres of land is irrigated. Cost of each cubic meter of treated effluent is 12rupees.3

Sl no	Object	Cost (rupees)	Total cost (rupees)
01	Pumping cost	3,18,990	3,18,990
02	Labours (4 Nos) charge 12000Rs x 4 x 12 months	5,76,000	5,76,000
		Total Cost	8,94,990

Over all Income = Total Income in rupees - Total Cost in rupees

= 9,66,972– 8,94,990

∴ Over all Income = 71,982 rupees

5. CONCLUSION

- In our case study it was noted that Yadgir city does not have any treatment unit and discharges the sewage water directly into the Doddanala tributary which ultimately joins river Bhima, so the river gets polluted, hence by treating these sewage and providing the effluent for the irrigation purpose pollution of the river will be avoided, When the water demand for agriculture is low during rainy season, the effluent can be safely discharged into the river as the dilution factor is high.
- The nutrient enriched effluent can be utilized for increasing the productivity of the irrigated agriculture land and generate financial resources for self sustainability of treatment infrastructure.
- The population study was made as per the census and population projection for the design period of thirty years was 1,93,046, the total sewage discharge is 21 mld.
- The integrated application of Remote sensing data, toposheets, revenue maps, wardwise maps and GIS software clearly indicates the necessity of two treatment plants of capacity 14 mld in zone-I of RL 366m, and 7 mld in zone-II of RL 367m, so that the sewerage system of the whole city can be designed under gravity flow with a zero energy consumption.
- The treated effluent is designed to be stored at an RL 386m, such that the water can be supplied for irrigation of land by gravity flow.

- The storage tanks volume is designed for initial output of effluent for the design period of 15 years i.e 2032 having two storage tanks for 14mld, a provision is also made for providing one more storage tank of 7 mld for design period of 30 years.
- The study was done for a particular groundnut crop with a projected population for 2032, which works out for providing treated effluent to 122 acres of agriculture land in two seasons.
- The sludge generated in waste stabilization pond can also be used for resource generation for economical sustainability of treatment plants.

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