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Comprehensive Wastewater Analysis and its Management in Some Part of Nagpur City, Maharashtra, India using SRTM DEM, GIS and Remote Sensing Approach

Sushil S. Umbarkar[1], B.S. Manjare[1] and I.M. Daberao[2]

[1]Department of Geology, RTM Nagpur University, Nagpur, Maharashtra, India
[2]GSDA, Solapur, Maharashtra, India

Correspondence should be addressed to Sushil S. Umbarkar, sushilumbarkar2007@yahoo.co.in

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Abstract Remote Sensing (RS) and Geographical Information System (GIS) and SRTM DEM have been used by as an effective and powerful method. These information and visual analytical tools have been widely applied to improve monitoring and conservation of water resources and calculate changes in environmental conditions. This study comprises in two main parts. The first part covers the Nag River and Pioli River sub basins in Nagpur. These basins were analyzed in an Arc GIS 10.2 (Ver.) by using concerning spatial data and considering water pollution parameters, population density, capacity and number of treatment plants, and etc. The Nag river sub basin was selected as the study area based on population density, generated wastewater, distribution and type of wastewater treatment plants, population served, treatment capacity and treated wastewaters, which are gained as the study area as a result of GIS queries analysis, was inspected by using remote sensing technology. Hence, relationship between land use and land cover categories, watershed and water quality parameters were interpreted by using remote sensing and GIS techniques. The geospatial information from the remote sensing data provides more effective solution for sustainable environment development. In common consensus that the progress of spatial data analysis (DSA) is a key to sustainable land management with economic and urban development.
Keywords *Wastewater; Change Detection; Urbanisation; Sustainable Development*

1. Introduction

Sewerage is part of the city planning in the technical terms because the size and the network of the system are strongly related to the spatial location of the population and its density. GIS base provides an integrative platform for urban planning and sewerage system planning exercise, thus an attempt has been made to apply the technology of GIS, SRTM DEM and Remote Sensing in the planning of sewerage infrastructure. The development and maintenance of a comprehensive sewer system inventory should be regarded as an essential undertaking for all sewerage authorities. Urban land cover/land use changes are very dynamic in nature and have to be monitored at regular intervals for sustainable environment development. Remote sensing data, which is extremely essential for monitoring urban expansion and change detections studies (Lo, 1981; Mukherjee, 1987; & Quarmby & Cushine, 1989).

2. Database and Methodology

2.1. Data Used

Fallowing data were used for the analysis;

Table 1: *Satellite Images Information*

Satellite	Sensor	Path/Raw	Date of Pass
IRS - P6 (ResourceSat1)	LISS III	198 / 62	1 Oct. 2000 12 Oct. 2006
Space Shuttle Endeavor	WRS-2 C-band X-band	185/185	12 Oct. 2006

SRTM DEM

For given study, SRTM DEM was used and resample at a grid resolution of 90 m. The positional accuracy is within the sub pixel range when compared with 1:50,000 toposheets (Figure 2) which is down load from the web.

Toposheet

Survey of India toposheet No. 55 O/4 covers the part of entire Nagpur city, Maharashtra. Scale of this toposheet is 1:50000. Contour interval is of 20 meters.

Table 2: *A Characteristic of ResourceSat - 1 LISS III Image*

	Characteristics	LISS III
1.	Spatial resolution (m)	23.5
2.	Swath (km)	141
3.	Swath steering range (Deg.)	--
4.	Spectral bands Band 1 (Green) Band 2 (Red) Band 3 (NIR) Band 4 (SWIR)	 0.52 – 0.59 0.62 – 0.68 0.77 – 0.86 1.55 – 1.70
5.	Repetitive Coverage	24 days
6.	No. of quantization levels	7
7.	SNR at saturation radiance	>128
8.	Integration Time	3.5528 (2,3,4)10.6584 (5)

2.2. Tools Used

- Erdas imagine 9.1
- Geomatica 8.3
- Arcview 3.2
- Arc GIS 9.3

3. Study Area

The study area lies in Survey of India toposheet No. 55 O/4 bounded by the Latitudes 20^{0}35’ to 21^{0}44 N and 78^{0}15’ to 79^{0}40’ E Longitudes. For the present wastewater management studies the area covers the approximately 40 km^{2} area. The district is bounded by Chhindwara District of Madhya Pradesh on the North Bhandara District on the east, Chandrapur District of South and Wardha and Amravati District of Maharashtra on the West side. (Figure 1 & Figure 2).

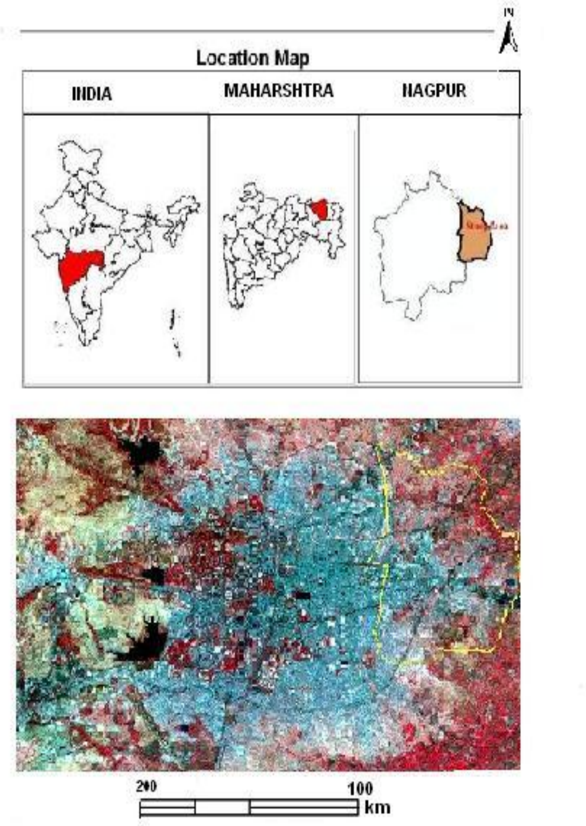


Figure 1: *Location Map of the Study Area*

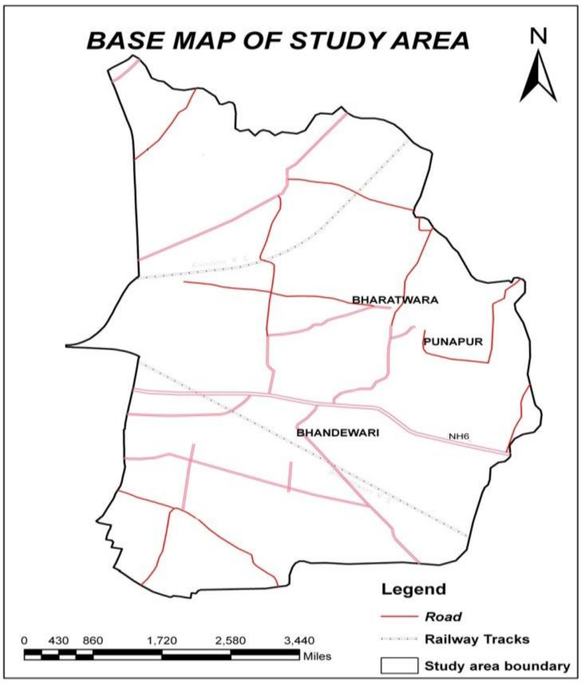


Figure 2: *Base Map of the Study Area*

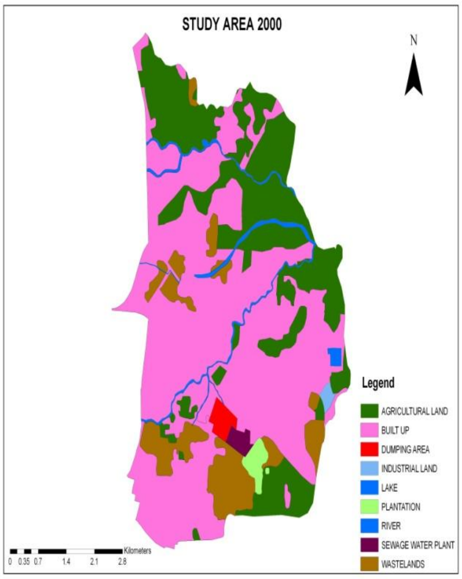
4. Landuse/Landcover

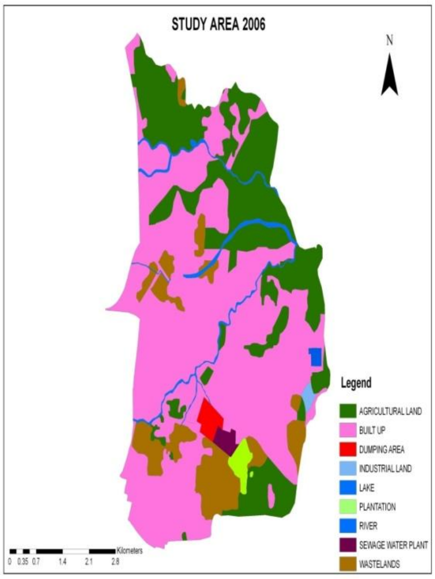
4.1. Land Cover / Land Use Changes

For mapping the supervised classification were used and made classes such as crop land, dense forest, open forest, barren land etc. (NRSA, 1989). The study area is situated in Bhandewadi, Punapur and Bharatwada which is covering the East part of the Nagpur city. The total geographical extension of the study area is 30.72 sq.km. From the of analysis the study areas has been classified into Nine classes such as agricultural land, built up, dumping area, industrial and lake, plantation, river, sewage water plant wasteland. In some part of the study area remarkable changes in the landuse/landcover have been observed which is supposed to be the outcome of human interference in the natural environment. According to the above studies of the landuse/landcover of Bhandewadi, Punapur, and Bharatwada villages of East part of Nagpur city showing the study area of 30.72 sq.km. The comparison of two assessment figure shows the statistically changes in the following classes year of 2002 and 2005 (Figure 3, Table 3).

Table 3: *Inventory of LULC in the Study Area 2000-2006*

LU/LC Classes	2002 year	2005 year	Change Detection 2002-2005
Agricultural Land	27.98%	27.29%	0.69%
Built up	57.44%	58.26%	0.82%
Plantation	00.97%	00.94%	0.03%
Wasteland	09.36%	09.25%	0.11%
Other Class (Industrial-land, dumping area etc.)	4.25	4.25	No changed





(a) **(b)**

Figure 3: *Landuse and Landcover Map of the Study Area (a-2002 & b-2005)*

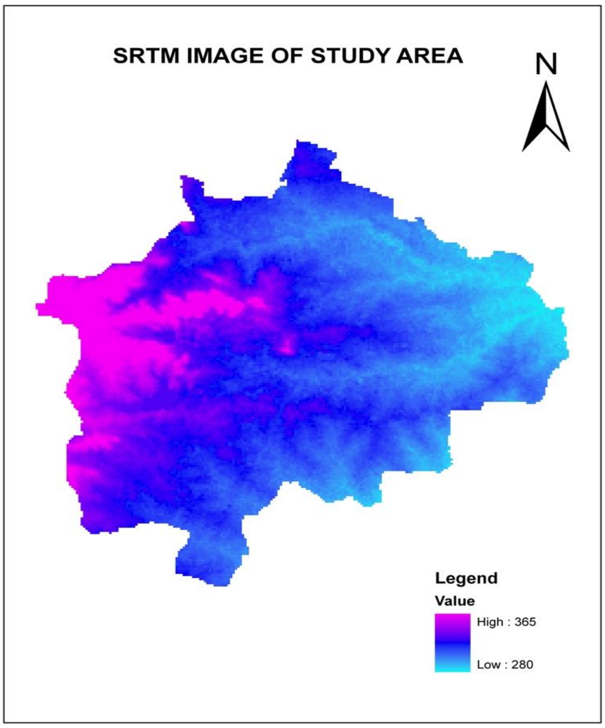


Figure 4: DEM Map Nagpur City (Including Study Area)

5. Water Analysis

The quality of water depends upon the water quality parameter like physical, inorganic and heavy metal parameters, the total quantity of dissolved solid represented by milligram per liter, the pH value or the relation of acidity with alkalinity and the nature of the dissolve element in any water development, it is essential to conduct chemical analysis of representative sample of wastewater and treated water to determine their properties. Sample of water are collected from treated wastewater at

Bhandewadi Sewerage Treatment Plant, wastewater sample at Bhandewadi, Bharatwada and Punapur in polythene bottle of one liter capacities (Table 4, 5 & 6).

Table 4: *Water Quality – Physical Parameter*

Sr. No.	Sampling Location	pH	Turbidity (NTU)	Total Suspended Solids (mg/l)	Total Dissolved Solids (mg/l)	Conductivity (µS/cm)
1.	Wastewater sample (Bharatwadi area)	7.92	114	87.75	470	680
2.	Treated Water (Bhandewadi)	8.42	3	162.8	390	560
3.	Wastewater before treated (Bhandewadi)	8.56	30	84.32	405	710
4.	Wastewater (Punapur)	8.76	52	120.45	394	720

Table 5: *Water Quality – Inorganic Parameter*

Sr. No.	Sampling Location	Total Alkalinity	Total Hardness	Calcium Hardness	Chloride	Sulphate	Sodium	Potassium	Oil & Grease
		As $CaCO_3$							
		mg/l							
1.	Wastewater sample (Bharatwada)	229.6	205	138	52.40	16.30	60.32	12.34	30.65
2.	Treated Water (Bhandewadi)	174	164	110	37.90	23.58	47.02	11.82	86.01
3.	Wastewater before treated (Bhandewadi)	234.4	209	120	36.97	19.88	52.50	10.63	14.95
4.	Wastewater (Punapur)	233.2	182	121	38.64	20.37	54.25	11.87	21.4

Table 6: *Water Quality – Heavy Metals*

Sr. No.	Sampling Location	Ni	Cd	Cr	Cu	Pb	Fe	Mn	Zn	Co
1.	Wastewater sample (Bharatwada)	0.025	ND	ND	2.098	0.580	8.969	0.299	0.224	0.005
2.	Treated Water (Bhandewadi)	ND	ND	ND	0.019	ND	0.183	0.015	ND	ND
3.	Wastewater before treated (Bhandewadi)	ND	ND	ND	0.012	ND	1.547	0.096	0.002	ND
4.	Wastewater (Punapur)	ND	ND	ND	0.020	ND	2.331	0.173	0.086	ND

ND – Not detectable

5.1. Chloride

Water containing less than 250 ppm chloride is satisfactory for water supply, agricultural or industrial use. 500 ppm of chloride water gets a disagreeably salty use. However animal can use water containing as much as 4000 ppm of chlorine. The limit of Cl concentration for drinking water is specified 600 mg/L (WHO, 1993).

5.2. Potassium

Relatively high levels of potassium are utilized by growing plant. It is also essentially for the same carbohydrates transformation crop yield are generally great reduced in potassium deficient soils the higher the productivity of the crop. The potassium is varying from 12.34 to 10.63 mg/l.

5.3. Sulphate

The sulphate values ranges from 16.30 to 23.58 mg/l. the limit of drinking water is 250 mg/l. The sulphate ions are one of the major anions occurring in natural water. Sulphate is important in both public and industrial water supplies. Its cathartic effect upon human when it is presented in excessive amount.

5.4. Temperature

The parameter of temperature is basically important parameter for its effects on the chemistry and biological reactions in the organisms in water; the temperature was measured by the thermometer on the spot.

5.5. Turbidity

Turbidity in water is due to colloidal and extremely fine dispersion. Suspended matter such as clay, silt finely divided organic and inorganic matter; phytoplankton and other micro-organisms also contribute to turbidity. Turbidity measurement is helpful to follow the course of self-purification of rivers and streams. The values ranges in the study area are 3 to 114.

5.6. Total Dissolved Solids

Total dissolved solids in any sample can be represented by dissolved and particulate organic and inorganic matter. The TDS values in the study area ranges from 390 to 470 mg/l. Higher the TDS shows the longer residence period of water. (Davis & De Wiest, 1966).

5.7. Electric Conductivity

Conductivity of a water sample is measure of the ability of the sample to carry electric current. The presence of salt and contamination waste water increase the conductivity of water consequently a sudden shine in conductivity in water will indicate addition of some pollutant to it. The electric conductivity values ranges from 560 to 720 μS/cm. The maximum limit of EC in drinking water is prescribed as 1500 μS/cm (WHO, 1993). The high conduction observed can be attributed high chloride concentration in groundwater (Davis & De Wiest, 1966).

5.8. pH

pH is a scale to measure intensity of acidity and alkalinity of hydrogen ions concentration. pH of fresh water varies considerably and mainly depends on concentration of carbonates, bicarbonate and free

CO_2 etc. The pH is an important indication of its quality and provides important information in many types of geochemical equilibrium. The pH values ranges from 7.96 to 8.76. The values of Punapur area is 8.76 which is higher than the WHO values.

5.9. Total Hardness

The soap consuming capacity of water is known as Hardness. In other word Hardness is the properly of water which prevent lather formation with soap and increased the boiling point of water. Principal cat ions imparting hardness are calcium and magnesium; however other cations such as strontium, ferrous ions, manganese ions, etc. can also contribute to hardness. The values of the Total Hardness in the study are ranges 182 to 209 mg/L. The union responsible for hardness may carbonates, sulphates, chlorides, nitrates and silicates, etc. The water attains hardness largely from their contact with soil.

5.10. Total Alkalinity

Alkalinity is a measure of the concentration of such ions in water that would reacts to neutralize hydrogen ions or Alkalinity is that a measure ability of the water to neutralize or “assimilate” acids. Alkalinity indicated the capacity of sample to maintain this equilibrium in the wake of additions of acids. Alkalinity imparts bitter taste to water and makes it unpotable. The values ranges in the study area are 174 to 234.4 mg/L.

6. Conclusion

The satellite data and GIS techniques provides an integrative platform for urban planning and sewerage system planning exercise, thus an attempt has been made to apply the technology of GIS, SRTM DEM and Remote Sensing in the planning of sewerage infrastructure. The development and maintenance of a comprehensive sewer system inventory should be regarded as an essential undertaking for all sewerage authorities. Estimate wastewater flow of the year 2020 is calculated by using statistical method of simple regression for projected population of the year 2020 is 28, 56, 068 lakhs. By using pollution load formula – 47, 28, 96, 021 ltrs, wastewater generates. According to this study the city has immediate demand of 300 MLD (wastewater) sewerage treatment plant over 300 MLD sewerage water that unnecessarily goes into Nag River. At the Bhandewadi, the Bharatwada and the Punapur villages are using water of the Nag River for agricultural irrigation and domestic purposes ultimately polluted water threatens crops, soil quality, and public health. Poorly managed water supply and sewerage services threatens public health and environmental harm to ensure that these services managed a significant legislative and regulatory framework must be complied with by those responsible for the provision and management of these services; it is important that planners are aware of the legislative and regulatory framework relating to sewerage services.

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