Pollution Prevention study using Remote Sensing and GIS: A model study from visakhapatnam district, Andhra Pradesh

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ABSTRACT

The present Studies Involves to develop a base line data and existing environmental conditions to the GIS database to holistically assess and manage environmental and non-environmental resources used by Industrial investors and other land and water users. The implementation of the Geographical Information System (GIS) will bring positive benefits through the generation of information and creation of digital databases with information on Air, Water Quality, Health and Hygiene and streamlines the decision making process. IRS-P6, LISS-IV geo coded Remote sensing Satellite data and top sheets from Survey of India (SOI) are acquired for primary analysis.

The present study has been carried out in nine (9) mandals namely Nakkapalli ,Elamanchilli,S. Rayavaram, Achchutapuram, Rambilli, Anakapalle, Munagapaka, Kasimkota, Paravada of Visakhapatnam District, covering an area of 1355 Sq.km. The study area is located between north latitudes 17° 19' and 17° 46'"and east longitudes 82°35' and 83°10' and is covered in the survey of India topographical map numbers 56H65 K/10,11,13,14,15M 65 O/1 and 2.

Using Visual Interpretation technique different thematic maps are prepared like land use/land cover, base map, village information, drainage maps These thematic maps were scanned and digitized using AutoCAD and converted into GIS. Topology is created by linking the spatial data file and attribute data file. GIS overlay analysis derived maps like surface water Table, surface water use, surface water quality, was carried out to find out the above parameters pollution lodes in the study area, Finally integrating of the all the above maps sensitive zone maps has developed. This kind of studies is very useful for Pollution Prevention in industrial areas and also useful for the planners decision makers for management and monitoring of industrial areas.

Keywords: pollution prevention, industrial area, Remote sensing, GIS

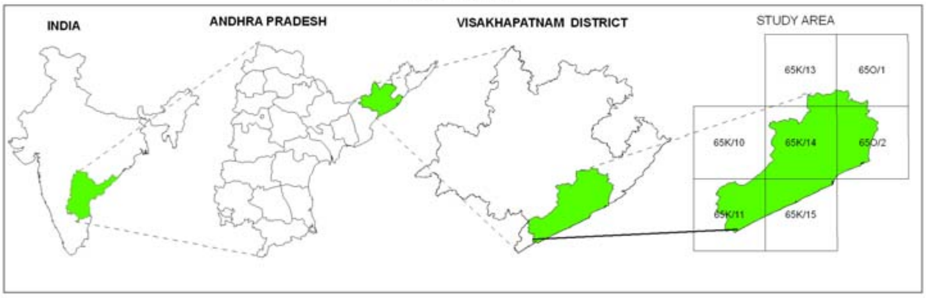
1. Introduction:

Scientific management of natural resources, in order to ensure their optimal utilization, keeping in view of conservation, environmental and socio-economic needs is a basic requirement. The extensive use of natural resources for economic development is leading to depletion of the finite natural resources, which clearly indicate that we cannot go on, forever at this rate of economic development. To resolve the issue between economic development and conservation of natural resources, the main requirement is availability of accurate, reliable, timely and up-to-date spatial information. Emergence of remote sensing as a powerful technology for Mapping and monitoring of natural resources and environment .Proper planning, management and monitoring of the natural resources depend on the availability of accurate land use information. The integration of resources data generated in the areas of geology, geomorphology, soil, forests, land use, groundwater, socio-economics, environment etc. can lead to identification of homogeneous land units having unique combination of characteristics and hence specific suitability in terms of scientific land utilization to increase the land productivity without compromising long term productivity and the environmental quality. Any anthropogenic activity is expected to cause some impact on the surrounding environment. The impacts may be adverse or beneficial. However, mankind as it is developed today cannot live without taking up these activities for his food, security and other needs. Consequently, there is a need to harmonize developmental activities with the environmental concerns.

It is desirable to ensure that the development options under consideration are sustainable. In order to achieve the above-mentioned goal, a baseline environmental study has been conducted within the study area and interpreted with the help of GIS tools. GIS is best utilized for integration of various data sets to obtain a homogeneous composite land development units which helps in identifying the problem areas and suggest conservation measures. This study will set a new trend in the industrial sector with concern for sustainable development and clean environment.

2. Study Area:
The study area is the part of the Visakhapatnam district, one of the nine coastal districts of Andhra Pradesh, is located in the north-eastern part of the State situated adjacent to the coast and where rapid development will take place in terms of industrialization. The study area is located between north latitudes 17° 19' and 17° 46'"and east longitudes 82°35' and 83°10' and is covered in the survey of India topographical map numbers 56H65 K/10,11,13,14,15M 65 O/1 and O/2. The area is under influence for fast development of urban agglomeration and industrial growth with mega industries for petroleum, Pharma parks . The study area is covered in Narsipatnam and Visakhapatnam revenue divisions. The study area is situated along the coastline from Nakkapalli mandal to Paravada mandal where the future development for industrialization will take place. It also includes the Anakapalli, Kasimkota, Munagapaka, Achchutapuram, Rambilli, Elamanchili and S.Rayavaram Mandals. Out of 246 revenue villages, Anakapalle (Class-II) and Elamanchilli (Class-III) are the major towns in the study area. The study area is covered an area of 1314 Sq.Km.

LOCATION MAP



3. Study Objectives:

1. Preparation of thematic maps using survey of India toposheet and satellite imagery using visual interpretation Technique.
2. Colleation of collateral data from different deportments and creation of attribute data of thematic maps using GIS tools.
3. Preparation of final surface water quality map.
4. Identification of surface water pollution sensitivity Map.

4. METHODOLOGY

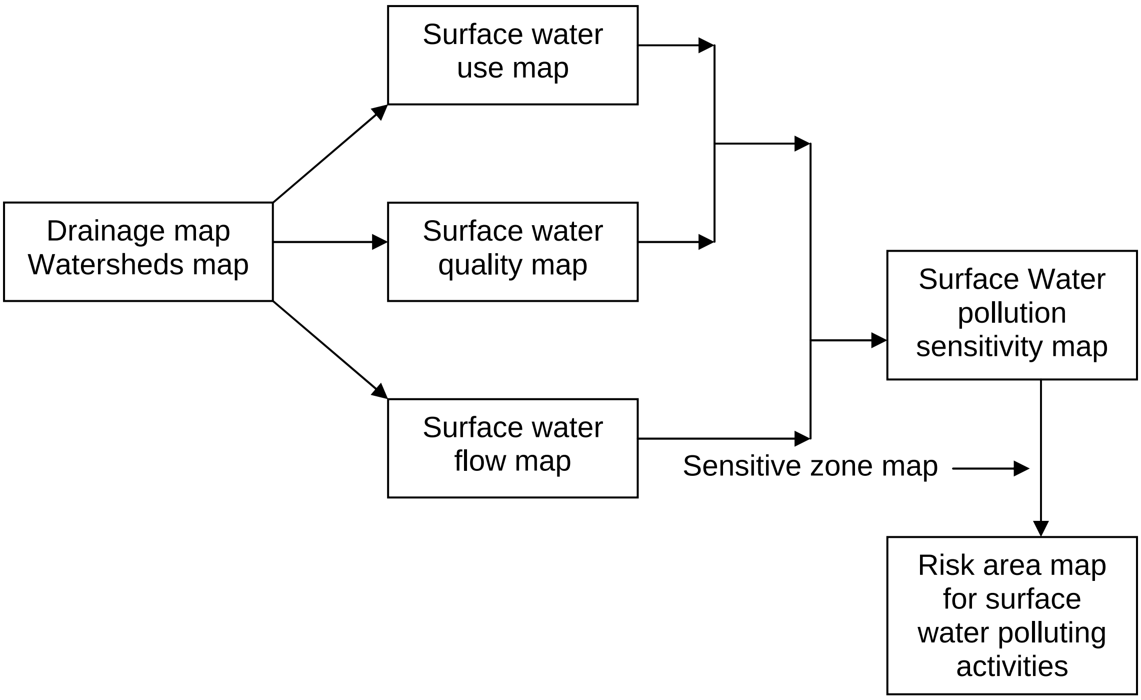
4.1 Data Used
Different data products required for the study include the56H65 K/10,11,13,14,15M 65 O/1 and O/2 toposheets which are obtained from Survey of India (1:50,000) and fused data of IRS – 1D PAN and LISS-III satellite imagery from National Remote Sensing Centre (NRSC), Hyderabad.

3.2 Database Creation
IRS-ID PAN and LISS-III satellite imageries are georeferenced using the ground control points with SOI toposheets as a reference and further merged to obtain a fused, high resolution (5.8m of PAN) and colored (R,G,B bands of LISS-III) output in EASI/PACE v6.3 Image processing software. The study area is then delineated from the fused data based on the latitude and longitude values and a final hard copy output prepared which is further interpreted visually for the generation of thematic maps. These thematic maps (Raster data) are converted to vector format by scanning using an A0-Flatbed Deskjet scanner and digitized in AUTOCAD 2000. The map is further edited in ARC/INFO and final hardcopy output is prepared using ARC/VIEW GIS software. The methodology adopted for creation of database is given in Fig. 1.

3.2.1 Spatial database:
Thematic maps like base map and drainage network maps are prepared from the SOI toposheets on 1:50,000 scale using AutoCAD and Arc/Info GIS software to obtain a baseline data. All the maps are scanned and digitized to generate a digital output was prepared using visual interpretation technique from the fused satellite imagery (IRS-ID PAN + LISS-III) and SOI toposheets along with ground truth analysis.

3.2.2 Attribute database:
Fieldwork was conducted and groundwater samples were collected from predetermined locations based on the drainage network maps of the study area. The water samples were then analyzed for various physico-chemical parameters adopting standard protocols [5]. The water quality data thus obtained forms the attribute database for the present study (Table 1).

3.3 Integration of Spatial and Attribute Database
The spatial and the attribute database generated are integrated for the generation of Surface water pollution sensitivity map of selected water quality parameters like pH, alkalinity, chlorides, sulphates, nitrates, TDS, total hardness, fluorides and Water Quality The risks due to discharge of effluents into surface water are determined in terms of surface water pollution sensitivity. The stretches of rivers and the corresponding watersheds are considered for this purpose. The surface water pollution sensitivity is determined based on the influencing factors of drainage, surface water quality, surface water flow and surface water use. The procedure involved is preparation of watershed, surface water quality, surface water flow and surface water use maps and suitably integrating them to arrive at the surface water pollution sensitivity map which depicts the areas of High, Medium and Low surface water pollution sensitivity (CPCB, 1996). The procedure followed for integration of the theme maps to finally arrive at the Risk area map for surface water polluting activities is given in the following flow chart.



5. RESULTS AND DISCUSSION

Drainage Network map

The study of drainage network for the present purpose is to understand – Whether the surface water flow can dilute the industrial pollutants To what extent the ground water will be affected by the industrial pollutants Sarada and Varaha are the major non-perennial rivers in the study area. The drainage pattern in the study area is mostly dendritic to sub-dendritic patterns controlled by fracture. The drainage map network of the study area is taken from SOI topo sheets. All the rivers, tributaries and water bodies shown on the toposheet are considered for preparation of the drainage map. Further these water bodies are updated from the latest satellite imageries for delineating the water spread in the tanks, reservoirs and rivers. This map forms the base for other theme maps related to surface water pollution sensitivity.

WATERSHED MAP
The study area drainage networks is divided into five major watersheds viz. drainage flows into Kaniti reservoir and Mehadri gedda (4F1C1), Sarada river basin (4F1B4), Varaha river basin (4F1B3) and Tandava river basin

(4F1B1). Out of these, Sarada and varaha rives are the principle rivers that flows in through the study area. The water divides between the catchments of Sarada River and Mehadri gedda runs thoroughly west north-west to east –south east. The micro-watersheds of the study area is shown in the watershed map

Surface Water Use Map

In the study area major portion covers under high surface water use due to Irrigation of surface drains and canals from Tandava and Sarada River. There is no possibility of low water use in the study area. The high water usage is identified in and around Anakapalli, Kasimkota, east of Elamanchili and west of Nakkapalli. There are small patches of high water usage is observed near koppa gunda palem, Polavaram and pedda uppalam due to the Aquaculture and Salt pans. The medium use of surface water is observed in Achchutapuram, S.Rayavaram and Rambili Mandals.

Surface Water Quality Map

The surface water quality map provides information about the quality of water in different water bodies of the study area. The water is classified as of high, medium and low quality in normative terms as under. (CPCB, 1996).

High - Water quality is well within the permissible limits and is fit for drinking/domestic purpose without conventional treatment but after disinfection.

Medium- Though the water quality is not within permissible limits, it can be used for drinking/domestic purpose after conventional treatment and disinfection. The water can also be used for irrigation purposes.

Low - The water is polluted and not fit for drinking purposes.

The surface water quality map is prepared based on data from the field data collection, drainage and watershed maps.

The drainage map with watersheds was selected. On this the location of water polluting industries and other sources of water pollution are marked.

The monitoring stations where the results of the water quality are available are marked. Based on the sources of pollution, monitoring data, field experiences and public complaints, the zones of ‘Low’, ‘Medium’ and ‘High’ water quality are marked.

Table- 18. Water Quality criteria for ‘E’ Class
(Specified by CPCB, 1979 and the Bureau of Indian Standards, 1982)

S.No	**Parameter**	**High Quality**	**Medium Quality**	**Low Quality**
1	Dissolved Oxygen (DO) mg/l	> 3	1.5 – 3	< 1.5
2	Total Dissolved Solids (TDS) mg/l	0 – 1050	1050 – 2100	> 2100
3	Chlorides (Cl-) mg/l	0 – 300	300 – 600	> 600
4	Sulphates mg/l	< 500	500 – 1000	>1000
5	Conductivity 25° Micro mho/cm	< 1250	1250 – 2500	> 2500
6	PH	6.5 – 8.5	4.5 – 6.5	<4.5 & >8.5
7	Fluoride	<1	1-1.5	>1.5

Table- 19.SURFACE WATER QUALITY DATA

Location	PH	TDS	TH	Total Alkality	CL	F	S	N
Sarada river near Ganaparti	8.40	240	148	173	31.9	0.41	bdl	bdl
YLB canal near Koppaka	8.40	265	129	158	36.8	0.56	9.7	bdl
Down stream of Sarada river near Anakapalle	8.90	280	124	233	31.9	0.41	11.9	0.905
YLB canal at Anakapalle	7.50	410	149	252	56.4	0.78	14.3	0.65
Sarada river near Sitanagaram	8.30	230	129	153	27	0.36	12.7	0.41
Mamidivakagedda canal near Ugginapalem	8.30	240	139	173	29.4	0.39	bdl	0.36
Sarada river near Kothur	8.40	260	124	208	27	0.39	bdl	bdl
Upstream of Sarada river near Anakapalle	8.30	265	129	193	29.4	0.42	13.8	0.44
Sarada river near Achchutapuram road	8.40	300	133	198	36.8	0.40	15.3	0.36
Rangavolugedda canal near Tallapalem	8.20	500	223	257	110	0.41	39.5	Bdl
Varaha river near Nakkapalli	8.80	450	137	229	38.8	0.34	Bdl	bdl

Surface Water Flow Map

This map is prepared based on the drainage and watershed maps and data collected form the irrigation department and field surveys. The flow rate in a river helps as a dilution factor to effluents and in self-purification (CPCB, 1996). The rivers / streams may be divided into three flow categories relative to each other to differentiate them according to their dilution capacity based on the flow characteristics as under:

High : Perennial flow/seasonal with high flow.
Medium : Seasonal with good flow/seasonal with medium flow.
Low : Seasonal with insignificant flow/seasonal with low flow.

Thus, the rivers/streams are divided into three surface water flow categories as High, Medium and Low. In the case of high surface water flow, the dilution factor being high, the surface water pollution sensitivity is low and in the case of low surface water flow, the dilution factor being low, the surface water pollution sensitivity is high.

The study area is drained by Sarada River which is having good flow during the rainy season. The Varaha River is also having the good amount of flow during the monsoon. As per the guidelines, the micro watersheds leading to the Sarada and Varaha Rivers are categorized as medium flow and the rest of area is fall under low flow zone .

Surface Water Pollution Sensitivity Map

The map has been generated by overlaying of Surface water use, surface water quality and surface water flow maps. Since the majority of the flow in the study area is low and high usage, there are few micro watersheds are under medium pollution sensitivity are possibility for dilution of treated effluents for setting up of medium water polluting industries in the study area

Overlay of surface water use and quality (Overlay-1)

Surface water quality \ Surface water use	High	Medium	Low
High	High	Medium	Medium
Medium	High	Medium	Low
Low	High	High	High

TABLE-21. (Overlay of overlay-1 and surface water flow)

Surface water flow \ Overlay-1	High	Medium	Low
High	High	Medium	Low
Medium	High	Medium	Medium
Low	High	High	High

Risk Area Map for Surface Water Polluting Activities

In the Surface water pollution sensitivity map, the zoning has been done without considering ‘Sensitive zones’ that are unsuitable for developmental activities due to legal restrictions, physical constraints etc. The risks on locating surface water polluting activities and the actual sites / zones available for locating surface water polluting activities are determined by superimposing the ‘Sensitive zone’ and the ‘Surface water pollution sensitivity’ maps and eliminating the sensitive zones. In the resultant ‘Risk area map for surface water polluting activities the ‘High’ risk areas are very sensitive to water pollution and hence no medium or large water polluting activities should be allowed in these areas.

There is possibility for setting up the medium water polluting industries around Dimili and Elamanchi villages and rest of the area is suitable for setting up the low water polluting industries.

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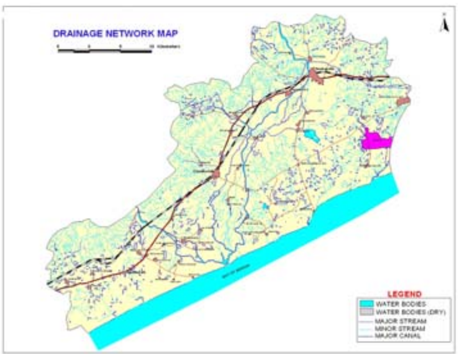
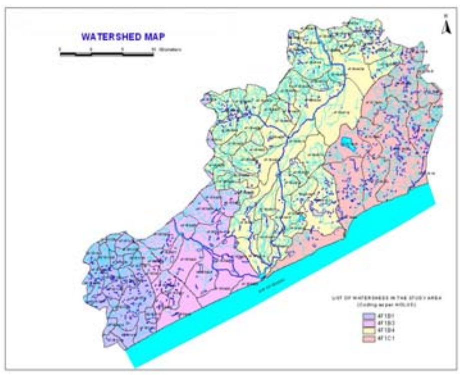
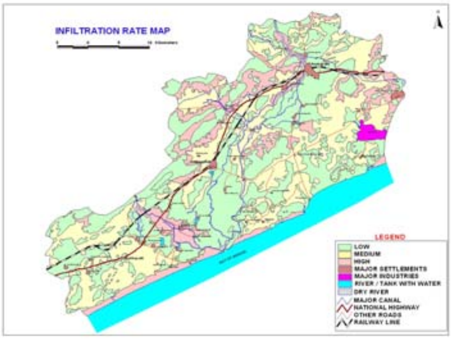
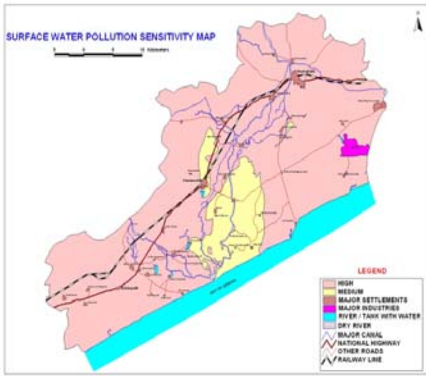


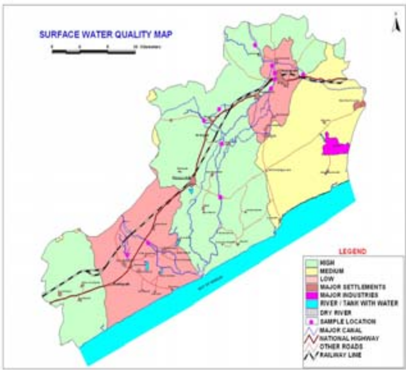



INFILTRATION RATE MAP
LEGEND
LOW
MEDIUM
HIGH
MAJOR SETTLEMENTS
MAJOR INDUSTRIES
RIVER / TANK WITH WATER
DRY RIVER
MAJOR CANAL
NATIONAL HIGHWAY
OTHER ROADS
RAILWAY LINE


SURFACE WATER FLOW MAP
LEGEND
LOW FLOW
MEDIUM FLOW
MAJOR SETTLEMENTS
MAJOR INDUSTRIES
RIVER / TANK WITH WATER
DRY RIVER
MAJOR CANAL
NATIONAL HIGHWAY
OTHER ROADS
RAILWAY LINE


SURFACE WATER USE MAP
LEGEND
HIGH
MEDIUM
MAJOR SETTLEMENTS
MAJOR INDUSTRIES
RIVER / TANK WITH WATER
DRY RIVER
SAMPLE LOCATION
MAJOR CANAL
NATIONAL HIGHWAY
OTHER ROADS
RAILWAY LINE


SURFACE WATER POLLUTION SENSITIVITY MAP
LEGEND
HIGH
MEDIUM
MAJOR SETTLEMENTS
MAJOR INDUSTRIES
RIVER / TANK WITH WATER
DRY RIVER
MAJOR CANAL
NATIONAL HIGHWAY
OTHER ROADS
RAILWAY LINE


SURFACE WATER QUALITY MAP
LEGEND
HIGH
MEDIUM
LOW
MAJOR SETTLEMENTS
MAJOR INDUSTRIES
RIVER / TANK WITH WATER
DRY RIVER
SAMPLE LOCATION
MAJOR CANAL
NATIONAL HIGHWAY
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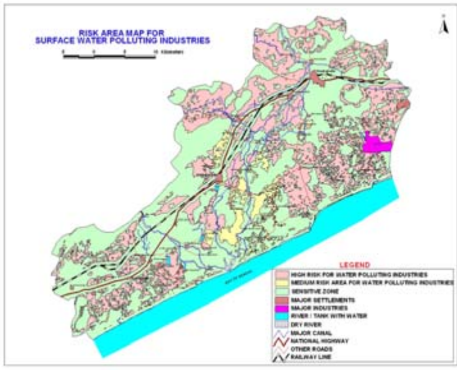
RAILWAY LINE


RISK AREA MAP FOR
SURFACE WATER POLLUTING INDUSTRIES
LEGEND
HIGH RISK FOR WATER POLLUTING INDUSTRIES
MEDIUM RISK AREA FOR WATER POLLUTING INDUSTRIES
SENSITIVE ZONE
MAJOR SETTLEMENTS
MAJOR INDUSTRIES
RIVER / TANK WITH WATER
DRY RIVER
MAJOR CANAL
NATIONAL HIGHWAY
OTHER ROADS
RAILWAY LINE