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Surface Water Quality Assessment and Mapping Using WQI and GIS- A Case Study from Hyderabad

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ABSTRACT *This paper deals with the decision making tool of complex water quality data, informing managers about the overall water quality status of Hussain sagar lake of Hyderabad District, Telangana, India by providing the spatio- temporal changes. Mapping was done using satellite data & GIS combined with GCP measurement of selected 21 sample points. Water quality data was collected for both pre-monsoon and post-monsoon seasons for two years. The water quality parameters included, Sacchi depth, Chl-a, TSS, pH, BOD, DO, Turbidity, TP, NO3-N, TDS, FC and TH. Using satellite data and in situ measurement data of water quality parameters, correlation were developed through geo-statistical analysis. The Q-Q plots were derived to evaluate sample distribution deviations. With the help of these multiple water quality parameters obtained through laboratory analysis water quality index (WQI) was calculated using NSFWQI and digital cartographic quality maps depicting the water quality over the lake for both the seasons respectively were prepared which revealed the bad quality condition of the lake projecting issues of concern.*

KEYWORDS : Hussainsagar Lake, Water Quality Parameters, Satellite Data, GPS, Water Quality Maps.

INTRODUCTION

Water quality is the main factor controlling the healthy and diseased states in both humans and animals. Surface water quality is an essential component of the natural environment and a matter of serious concern today. Anthropogenic influences as well as natural processes degrade the surface waters and their use for drinking, industrial, agricultural, recreation or other purposes. The water bodies are suffering because of negligence, pollution and are used for disposing of untreated domestic sewage and industrial effluents which adversely affect the aquatic ecosystem. The discharge of effluents and associated toxic compound in to aquatic system show impact on communities in the receiving aquatic water and cause a potential effect on human health and surround environment. Further these pollutants will enter ground water resulting in pollution.

To determine the existing status of water quality and to avoid the future water catastrophe, assessing and monitoring water quality using remote sensing in conjunction with in-situ measurement plays a significant role (Salama et al., 2009). However, in relation to the use of in-situ measurement and remote sensing observation there are constraints. Because of the spatial and temporal variation in water quality conditions, representative and reliable estimation of the quality of surface waters is necessary through regular monitoring and assessment. Multivariate statistical techniques are powerful tools for analyzing large numbers of samples collected in surveys, classifying assemblages and assessing human impacts on water quality and ecosystem conditions. These techniques provide the recognition of possible sources that affect water environmental systems and offer a important tool for consistent management of water resources as well as swift solution for pollution issues.

HYDERABAD URBAN AREA

Hyderabad Urban Agglomeration (HUA), the fifth largest metropolis in India, covering more than 775 sq. km area and is currently home to over 5.75 million persons. Out of the 1534 Sq. Km. of Hyderabad development authority area, the Municipal Corporation of Hyderabad (MCH) has 179 Sq. Km. The lake is located at 17°.36'N and7 8°.47'E at 510m above sea level is selected for the present investigations. Overall, the discharge of municipal sewage, industrial effluents, the storm water discharge containing diluted sewage and other impurities on the land surface from over 240 square kilometers area of watershed have resulted in dumping of high amounts of organic matter, nitrogen and phosphorous in to the water indicated by the increased eutrophication. This situation suggests a strong variability due to presence of anthropogenic sources from the catchment affecting the water quality. The study area is shown in the figure 1.1.

Figure 1.1 showing the location map of the study area, Hussain Sagar Lake.

RESULTS AND DISCUSSION

a) Collection and laboratory analysis of water quality samples

The field measurements were carried out in April and November months of 2013 and 2014 which is of pre-monsoon and post-monsoon season. At twenty one sampling points representative water samples were taken along with GCPs. The days were selected based on the satellites over pass. The positions of the sampling points were recorded by using GPS.

b) Data used

The study area was demarcated using Toposheets of 1:50,000 by identifying the district boundaries by Scanning, projecting, geo-referencing and digitizing toposheets of the area manually using ERDAS. Various land use / land cover features were studied and a base map was prepared by visual interpretation using toposheets and image of Landsat-8 sensor. Water samples were taken from the area using random sampling techniques.

c) Spatial database

The spatial database is prepared by using different thematic layers like base map of the study area, land use / land cover, drainage network from SOI topographical sheets on 1:50,000 scale using ERDAS, ArcGIS software to obtain baseline data. All maps are digitized to convert data into vector format. Land use / land cover maps are prepared by using GIS software through supervised classification. SOI topographical sheets, satellite data and GPS (global Positioning data) together used with ground truth data. The Figure 1.2 shows the GPS points and contour map of study area.

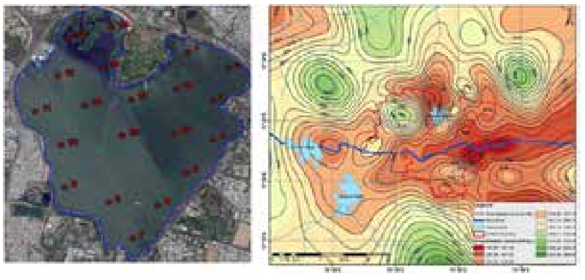

Figure 1.2 showing the GPS points and contour map of study area.

d) Attribute database

Surface water samples were collected from predetermined locations selected from the satellite imagery. The water samples taken from these locations were then analyzed for thirteen water quality physico-chemical parameters adopting standard protocols. The water quality data thus obtained is used as database for present study (Table 1.1). The standards prescribed by BIS were used for the calculation of water quality indices (BIS, 1991).

Calculation Water quality index (WQI)

Water quality index is regarded as one of the most effective way to communicate water quality (Sinha et al., 2004; Srivastava et al., 1994) In this a rating scale is fixed on the basis of importance and incidence on the overall quality of drinking water in terms of different physico-chemical parameters. For calculating WQI the National Sanitation Foundation water quality index (NSF, WQI) has the following mathematical structure is used:

NSF WQI = $WQI = \sum_{i=1}^{n} Q_i W_i$

Where,

Q_i = sub-index for ith water quality parameter;

W_i = weight associated with ith water quality parameter;

n = number of water quality parameters.

The WQI values calculated along with the quality parameters is exhibited in Table 1.1. Based on the water quality values, the water samples quality is categorized as Excellent, Good, Medium, Bad and Very bad (NSFWQI).

Table 1.1 showing the water quality parameters of the study area

Parameters	Mean Premonsoon (2013)	Mean Post Monsoon(2013)	Mean Premonsoon(2014)	Mean Post Monsoon (2014)	BIS (IS 10500-91)
pH	7.78	8.1	8.04	8.4	6.5-8.5
Secchi depth(cm)	28	30	30	1	--
Chl-a	8	10	10	6	--
Turbidity(NTU)	7.2	2.4	8.2	8.5	5
TSS (mg/l)	1200	1036	1400	1500	100
TP(mg/l)	7.2	13.38	9.6	8.9	No Relaxation
NO3-N(mg/l)	5.4	5.36	6	4.2	45
Temperature(°C)	30	29	30	28	--
Total Hardness(mg/l)	43.6	635.6	156	175	200
DO(mg/l)	2.26	2.35	2.15	2.03	5
BOD(mg/l)	269	351	216	205	30
TDS(mg/l)	680	376	820	862	500
FC(MPN/100ml)	1800	1980	1500	1654	10
WQI	35.42	35.14	34.14	34.28	BAD

Preparation of Quality maps and statistical Correlations:

The analysis data is correlated with the satellite image and water quality maps were developed using ArcGIS 10.1. Further Geostatistical analyses were carried to evaluation the spatial distribution and temporal variation of water quality data. The Q-Q plots shows normal distribution majorly. Fig 1.3 shows the spatial distribution of pH values and Geostatistical analysis.

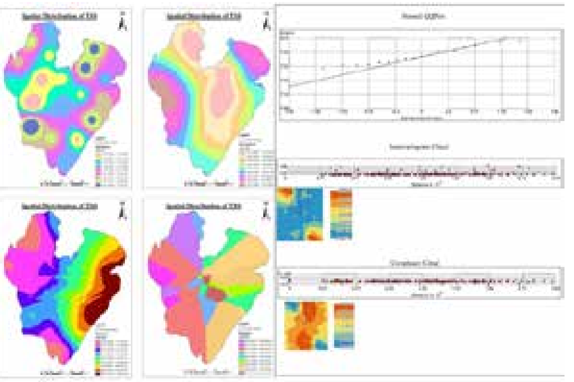

Fig 1.3 showing the spatial distribution of TSS pre-monsoon of 2013 & '14 and TDS post-monsoon of 2013 & '14 respectively and Geostatistical analysis of pH value.

CONCLUSION

The water quality data have been examined by different multivariate statistical techniques and is used to evaluate spatial and temporal variations of the lake basin. The statistical approaches show that, the domestic sewage and uncontrolled industrial effluent discharges are highly influencing the water quality. The seasonal values of WQI show variation in the two seasons in both the years where parameter concentrations show disparity . Result of water quality assessment clearly showed that most of the water quality parameters slightly higher in the wet season than in the dry season. Since there wasn't any precipitation at a recordable level the variations in the quality are not so demarcated but the pollution accumulation due to absence of dilution showed its prevalence. WQI values indicate comparatively a slight improvement in the index then earlier years which might be due to the aerators placed in the lake to enhance the oxygen circulation. The higher values of physico-chemical analysis of water in Hussain Sagar Lake can be attributed to various activities like discharge of untreated domestic sewage and industrial effluents, washing clothes, vehicles, animals and immersion of idols at the time of Ganesh festival contributing to the pollution of the lake. The present study reveals the nutrient loading have exceed the eutrophic condition and leading to a hyper eutrophic status.

Thus, this study illustrates the usefulness of spatial data predictions and statistical techniques for analysis and interpretation of complex data sets in water quality assessment, thereby understanding spatial variations and quality index in water quality for effective lake water quality management.

RECOMMENDATIONS

The uncontrolled and untreated waste water from the lake must be diverted through Interception and Diversion facilities. The effluents must be monitored for maintaining the standards prescribed by the pollution control board for various industries in the catchment area. More intensive and frequent water quality field measurements with simultaneous matchup images collection are recommended. The present study provides the baseline data for assessment of polluting sources and predicting the spatio- temporal variations in the contaminants.

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