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Assessment Of Surface Water Quality Of Deeporbeel Wetland

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ABSTRACT

Wetlands are under increasing stress due to urbanization and other anthropogenic activities, leading to their over exploitation and degradation. Deeporbeel wetland a permanent fresh water lake in a channel of the river brahmaputra of assam state in India has great biological and environmental importance and is the only ramsar site in the state. One of the major threats faced by the wetland is deterioration of its water quality. This paper presents the results of physico-chemical parameters measured during the post monsoon (2005) and pre-monsoon seasons (2006) and the computation of National Sanitation Foundation - Water quality Index (NSF-WQI) at fixed locations and comparison with base year (1989) data available only for 3 locations. Besides, point and non-point pollution sources, erosion, silt deposition and gully erosion have been identified as the major sources of deterioration of water quality. The results indicated that the wetland has reached medium water quality over the years from good quality in the year 1989. The conservation measures in respect of point and non-point sources as well as remedial measures for silt deposition and gully erosion are suggested.

KEYWORDS

Deeporbeel;
Heavy metals;
Physico-chemical;
Ramsar site;
Wetland.

INTRODUCTION

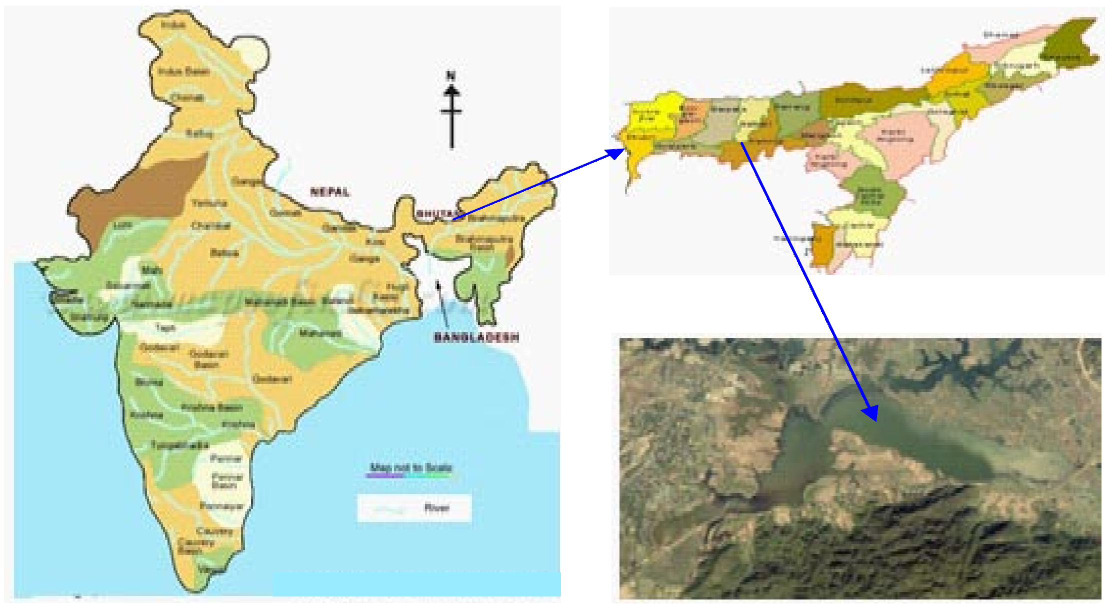
Water, the most vital resource for all kinds of life on the earth is adversely affected by all kinds of anthropogenic activities. An increasing population, coupled with industrialization and urbanization has created high water demand for various usages and this has resulted in heavy pressure on available surface and ground water resources. Pollution of the resource has resulted. The sources of pollution are sewage, domestic waste, industrial and agricultural effluents with impacts ranging from simple nutrients from non point sources to highly toxic substances from point sources[1]. Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation, and other factors, including human disturbance. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands are considered valuable because they clean the water, recharge water supplies, reduce flood risks, and provide fish and wildlife habitat. In addition, wetlands provide recreational opportunities, aesthetic benefits sites for research and education, and commercial fishery benefits[2,3,4]. Wetlands are under heavy pollution stress due to over exploitation and degradation of water resources owing to various anthropogenic activities. The interaction of man with wetlands has become a serious concern in recent years due to the rapid population growth coupled with increasing industrial, commercial and residential developmental activities leading to its heavy pollution by domestic waste, industrial effluent and agricultural runoff such as chemical fertilizers, insecticides, pesticides etc.[5, 6].

Deeporbeel wetland located in the Kamrup district of Assam state in India has been studied for the assessment of its water quality. It is a natural wetland having significant biological and environmental importance and is presently, experiencing serious threats due to bad water quality. The present paper reports the results of various physico-chemical parameters measured for computing the National Sanitation Foundation - Water quality Index (NSF-WQI), which has been applied for assessing the status of this water body. Taking 1989 as the base year, there was found to be considerable difference in recent years is predicted to worse in the future. It is imperative that the water quality be restored. The paper also deals with the erosion and silt problems contributing to the deterioration of wetland and suggested the remedial measures.

Deeporbeel wetland - the study area

Deeporbeel wetland is located between 91°36′ 39″E and 91°41′25″E longitude and 26°05′26″N and 26°09′ 26″N latitude, to the south of brahmaputra river in kamrup district, 18 km south west of guwahati city in assam. It lies at an altitude of about 50 meter above MSL and covers an area of about 4,000 ha. It is a large natural wetland having great biological and environmental importance, besides being the only major storm water storage basin for the guwahati city[7]. The wetland is endowed with rich floral and faunal diversity. It is also a huge congregation of residential water birds, harbours a large number of migratory waterfowl each year and interacts with the wild life of the adjacent rani-garbhanga reserve forest. In 1991 about 414 ha of the wetland was declared as Bird Sanctuary, a national wetland in 1994-95 and accorded wetland of international importance in 2002, which has been designated as a ramsar site.

The wetland is surrounded by the bharalu river basin on the east, basistha basin in the south east, kalmoni river on the west, jalukbari wetland on the north and rani - garbhanga reserve forest on the south. Figure 1 shows the location of the wetland. The national highway (NH-37) passes a little distance away from the eastern boundary of the wetland. The wetland has a mesothermal climate characterized by high humidity and moderate temperature. The minimum and maximum temperatures ranges between 7° to 26°C in january and 23° to 37°C in july/august respectively. The average annual rainfall in the area is 1733 mm and about 90% of the rain occurs between april and september. Relative humidity varies from 50% to 90%. Major part of the catchment area of the wetland is the reserve forest of rani - garbhanga



Map of India **Deeporbeel Wetland**

Figure 1: Location of Deeporbeel Wetland

forest and the run off water from the area flows into the wetland mainly through basistha and kalmoni rivers. Human activity exists on the eastern and northern parts of the wetland. Sewage from the eastern part of guwahati city flows into the wetland without treatment through basistha river.

EXPERIMENTAL

Advanced water quality monitoring techniques are conventional, automatic and remote sensing techniques. In the present study, the surface water quality of the wetland was assessed by collecting samples from six representative sampling locations after conducting reconnaissance survey. The samples were collected during post-monsoon (October-November, 2005) and for pre-monsoon season (April, 2006). The detail of sampling locations is given in TABLE 1. The grab samples were collected at a depth of about 25 cm between 8:00 to 9:50 A.M. in cleaned and dried 2 litres capacity polythene containers and labeled. Samples for DO measurement were collected separately in sterilized 300 ml capacity BOD bottles. The samples were analysed at regional environmental testing center (RETCEN) of assam engineering College, Guwahati for various water quality parameters.

Apart from physico-chemical parameters, analysis were also done for five heavy metals viz. Pb, As, Hg, Zn and Mn at the Institute Instrumentation Centre (IIC), IIT Roorkee. The samples were initially preserved in nitric acid medium at less than pH 2.0.

The data for 1989 year has been obtained only for locations i.e. D_1, D_2, D_3 and D_6 from state government agencies. The parameters assessed are temp., pH, conductivity, TS, TDS, TSS, turbidity, NO_3^-, PO_4^-, Cl^-,

TABLE 1: Sampling locations

Sampling station	Sampling station code	Latitude	Longitude	Description of station
1	D1	26°6′2.96″	91°40′46.18″	Main Inlet Channel
2	D2	26°8′07.11″	91°40′04.92″	Residential Area
3	D3	26°8′10.25″	91°38′00.57″	Industrial Area
4	D4	26°8′13.86″	91°38′29.10″	Outlet Channel
5	D5	26°7′16.89″	91°39′04.13″	Middle of Wetland
6	D6	26°6′40.57″	91°38′09.55″	Near Hilly Catchment at Southern Fringe

TABLE 2: Average water quality parameters (Post-monsoon, 2005)

Sampling location	Temp. (°C)	Temp. variation (°C)	pH	Conductivity μ mho/cm	DO mg/l	BOD mg/l	COD mg/l	TS mg/l	TDS mg/l	TSS mg/l	Turbidity NTU	NO_3 mg/l	PO_4 mg/l	Cl mg/l
D1	25.2	0.5	7.3	125	5.2	8	18.6	233	70	163	19	1.8	2.3	12.2
D2	25.6	0.5	7.5	158	3.8	12.6	22.6	160	90	70	7	2.5	3.4	15.0
D3	26.8	0.3	7.7	155	3.3	16	36	153	70	90	12	1.9	2.9	15.8
D4	25.3	0.6	7.8	102	5.1	9.3	32.6	130	74	56	11	1.4	3.9	15.7
D5	27.8	0.3	7.5	123	6.5	7.3	11.5	113	70	43	7	0.17	1.9	13.3
D6	28.3	0.2	7.4	185	5.2	13.3	20	210	80	130	15	2.3	3.9	16.6

TABLE 3: Average water quality parameters (Pre-monsoon, 2006)

Sampling location	Temp. (°C)	Temp. variation (°C)	pH	Conductivity μ mho/cm	DO mg/l	BOD mg/l	COD mg/l	TS mg/l	TDS mg/l	TSS mg/l	Turbidity NTU	NO_3 mg/l	PO_4 mg/l	Cl mg
D1	26.2	0.5	7.2	112	4.7	10	16	153	90	63	13	0.9	1.3	12.9
D2	27.1	0.5	7.4	113	3.6	13	26	130	80	50	6	1.6	2.3	15.4
D3	26.7	0.3	7.5	124	3.2	14	36	163	83	80	9	1.7	2.7	17.0
D4	27.2	0.6	7.5	114	4.9	10	32	120	77	43	9	1.1	3.0	15.6
D5	26.1	0.3	7.2	110	4.8	9	15	103	63	40	7	0.15	1.3	13.5
D6	26.6	0.2	7.3	170	5.5	13	19	166	83	83	10	1.6	2.9	16.5

heavy metals. DO, BOD and COD. The analysis was done as per standard methods[8,9] and the results of analysis for both the seasons for all the locations are given in TABLE 2 and 3.

RESULTS AND DISCUSSIONS

Using the parameters achieved experimentally, National Sanitation Foundation - Water quality Index (NSF-WQI) has been computed. The ratings of NSF-WQI indices are given in TABLE 4. The sub-index value of the base year 1989, 2005 and 2006 are given in TABLE 5 to Table 8. A comparison of NSF-WQI of 2005 and 2006 with 1989 base year is shown in TABLE 9.

The above tables clearly shows that water quality of wetland in the year 1989 for both the seasons was 'Good' meaning thereby that the biological environment of the wetland was suitable for ecosystem development and provided life support module for a number of aquatic/terrestrial plants and ani-

TABLE 4: Rating scale for the NSFWQI (National sanitation water quality index)[11]

Index value	Rating	Indicating Colour
0 and <=25	Very bad	Red
>25 and <=50	Bad	Orange
>50 and <=70	Medium	Yellow
>70 and <=90	Good	Green
>90 and <=100	Excellent	Blue

TABLE 5: Sub-index value (Base year 1989, Pre-monsoon) (Water quality index)

Parameter	Location D1		Location D2		Location D3		Location D6	
	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value
D.O.(mg/l)	6.2	73	5.9	72	6.1	74	6.6	77
pH	6.3	64	6.6	75	6.8	83	6.9	86
BOD (mg/l)	3	67	2	80	3	67	2	80
NO_3^{-1} (mg/l)	0.25	97	0.30	97	0.40	97	0.20	97
PO_4^{-3}(mg/l)	0.65	53	0.65	53	0.80	47	0.65	53
Temp. (^{0}C)	20.5	-	23.0	-	21.8	-	20.0	-
Turbidity(NTU)	9	78	9	78	8	80	9	78

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TABLE 6: Sub-index value (Base year 1989, Post-monsoon)

Parameter	Location D1		Location D2		Location D3		Location D6	
	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value
D.O.(mg/l)	5.9	70	6.1	74	5.7	68	6.0	72
pH	6.8	83	6.6	75	6.8	83	6.9	86
BOD (mg/l)	4	61	2	80	3	67	2	80
NO_3 (mg/l)	0.2	97	0.30	97	0.41	97	0.2	97
PO_4 (mg/l)	0.65	53	0.60	55	0.82	46	0.70	50
Temp. (°C)	21.7	-	22.5	-	23.2	-	21.5	-
Turbidity(NTU)	10	76	10	76	11	74	12	72

TABLE 7: Sub-index value (Post-monsoon, 2005)

Parameter	Location D1		Location D2		Location D3		Location D4		Location D5		Location D6	
	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value
D.O.(mg/l)	5.2	62	3.8	39	3.3	31	5.1	58	6.5	89	5.2	69
pH	7.3	93	7.5	93	7.7	91	7.8	90	7.5	93	7.4	93
BOD (mg/l)	8	42	12.6	26	16	18	9.3	37	7.3	45	13.3	24
NO_3 (mg/l)	1.8	95	2.5	93	1.9	95	1.4	96	0.17	97	2.3	94
PO_4 (mg/l)	2.3	25	3.4	19	2.9	22	3.9	17	1.9	28	3.9	17
Temp. (°C)	25.2		25.6		26.8		25.3		28.9		29.4	
Temp.Variation(°C)	0.5	91	0.5	91	0.3	92	0.6	91	0.3	92	0.2	92
Turbidity (NTU)	19	62	7	82	12	72	11	74	7	82	15	67
Total solids (mg/l)	233	68	160	78	153	79	130	81	113	82	210	71

TABLE 8: Sub-index value (Pre-monsoon, 2006)

Parameter	Station D1		Station D2		Station D3		Station D4		Station D5		Station D6	
	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value
D.O.(mg/l)	4.7	54	3.6	36	3.2	29	4.9	58	4.8	55	5.5	72
pH	7.2	92	7.4	93	7.5	93	7.5	93	7.2	92	7.3	93
BOD (mg/l)	10	34	13	25	14	23	10	34	9	38	13	25
NO_3 (mg/l)	0.9	96	1.6	95	1.7	95	1.1	96	0.15	97	1.6	95
PO_4 (mg/l)	1.3	34	2.3	23	2.7	23	3.0	21	1.3	34	2.9	22
Temp.°C	26.2		27.1		26.7		27.2		26.1		26.6	
Temp.Variation°C	0.5	91	0.5	91	0.3	92	0.6	91	0.3	92	0.2	92
Turbidity NTU	13	70	6	84	9	78	9	78	7	82	10	76
Total solids(mg/l)	153	79	130	81	163	77	120	82	103	83	166	77

mals. On the other hand, the water quality has deteriorated over the years due to large number of activities taking place in the surrounding areas of the wetland and in year 2006, it has reached to medium water quality i.e., the water is loaded with toxic pollutants from domestic sewage, industries, agricultural, commercial and other activities. At this stage, suitable conservation measures are needed to further check the pollution of the wetland and to bring the wetland to its original state.

In lakes and wetlands, phosphate is usually the limiting nutrient for algal bloom. Although the presence of nitrate is also important. The PO_4^{-3} increased from 1.9 (base year) to 3.9 mg/l during post-mon-

TABLE 9: Comparison of NSF-WQI

Parameter	Station D1		Station D2		Station D3		Station D4		Station D5		Station D6	
	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value	Value	Sub-index value
D.O.(mg/l)	4.7	54	3.6	36	3.2	29	4.9	58	4.8	55	5.5	72
pH	7.2	92	7.4	93	7.5	93	7.5	93	7.2	92	7.3	93
BOD (mg/l)	10	34	13	25	14	23	10	34	9	38	13	25
NO_3^{-1} (mg/l)	0.9	96	1.6	95	1.7	95	1.1	96	0.15	97	1.6	95
PO_4^{-3} (mg/l)	1.3	34	2.3	23	2.7	23	3.0	21	1.3	34	2.9	22
Temp. °C	26.2		27.1		26.7		27.2		26.1		26.6	
Temp.variation°C	0.5	91	0.5	91	0.3	92	0.6	91	0.3	92	0.2	92
Turbidity NTU	13	70	6	84	9	78	9	78	7	82	10	76
Total solids(mg/l)	153	79	130	81	163	77	120	82	103	83	166	77

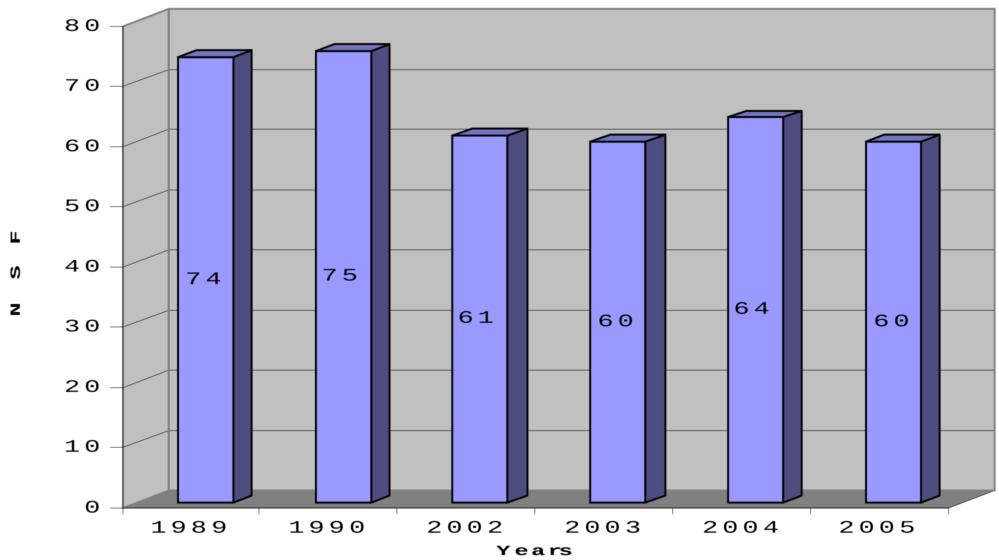

Figure 2: Temporal variation of NSFWQI for sampling location D3

soon (2005) and from 1.3 mg/l to 3.0 mg/l during pre-monsoon (2006) at the various sampling locations. According to Metcalf and Eddy[10], algal blooms tend to occur if the concentration of inorganic nitrogen and phosphorous exceed 0.3 mg/l and 0.01 mg/ l respectively and it is because of this reason that the wetland also suffers from serious eutrophication problem.

Data for only one location D3 was available for several years and accordingly, NSF-WQI was calculated and compared with base year index. The NSF-WQI index of D3 for all these years has been graphically represented by figure 2 which indicates that there was temporal variation of NSF-WQI index which is not very much significant.

Erosion and silt deposition

The catchment area of the wetland has been delineated from year 1972 top sheet. The total catchment area of 223.30 km^2 consists, of wetland area (220.20 km^3) and extra catchment for outlet (Khana river) of 3.10 km^2. It is divided into 3 side catchment; main inlet channel (Basistha and Morabharalu river), Inlet channel (Kalmoni river) and area contributing to direct runoffs (Figure 3). The land use indicates that 61% of the catchment area is forest followed by 23% used as crop land, 6% as grazing, 7% as settlement area and remaining as barren land. Land use pattern since year 1972 has been computed and it was found that the forest area in the wetland

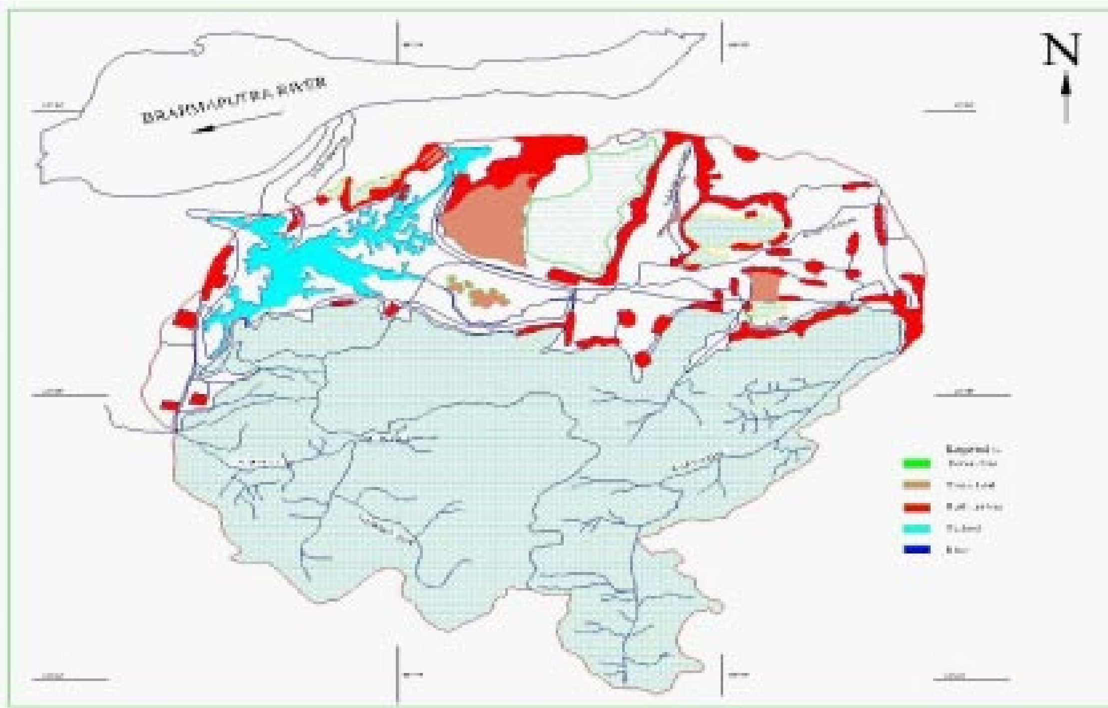

Figure 3: Catchment area of deeporbeel wetland (Based on 1972 Toposheet)

catchment has decreased by 13.22 %, barren land has increased by 33.22 %, settlement areas increased by 27.41 %, grazing land almost ceased to exist (98.37 % reduction) and agricultural land decreased by 46.41 %. Over the years, there has been a decrease in the soil erosion rate, which could be attributed to the change in land use, particularly, conversion of agricultural and grazing land into settlement areas. The decrease in forested area and increase in barren land has increased the soil erosion, but the rapid increase in the settlement area has decreased the overall soil erosion during the year 2005. Figure 4,5,6 and 7 compare the percentage of the land use pattern in the wetland catchment and the percentage of the gross soil loss for the years 1972 and 2005.

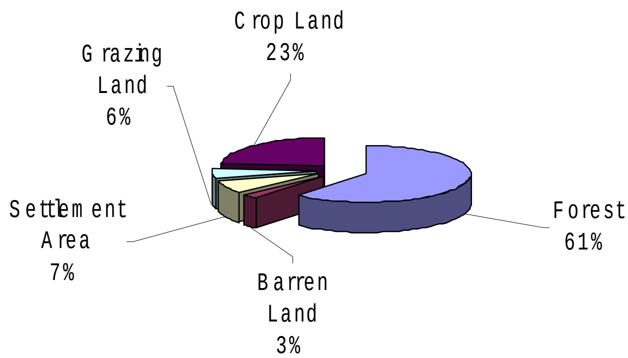

Figure 4: Land use pattern during year 1972

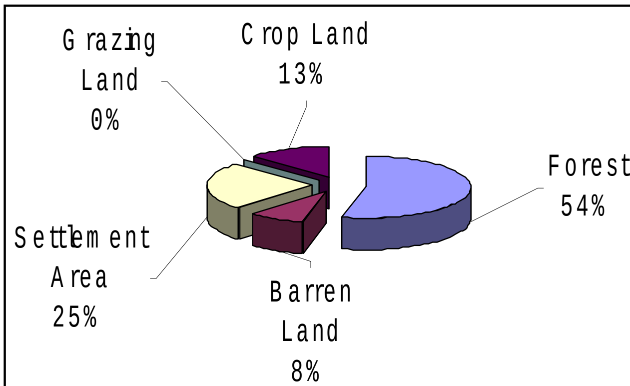

Figure 5: Land use pattern during year 2005

Gully erosion

Thirteen gullies were identified in the catchment area and accordingly, the control measures are suggested. If the gullying process in the three active gullies is not checked, the potential soil loss will be more than the total soil loss that has occurred from the thirteen gullies. This eroded soil will ultimately be carried by surface runoff into the wetland, thus, adding to the siltation problem. To check the gully-

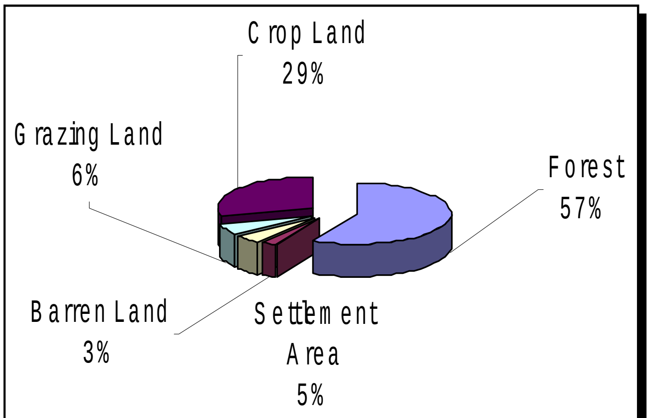

Figure 6: Percentage soil loss during year 1972

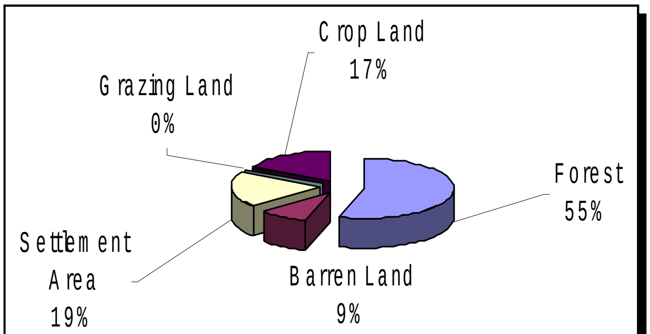

Figure 7: Percentage soil loss during year 2005

ing process, total 57 check dams will be required involving an estimated cost of about 0.6 million indian rupees. To further check gullying process, vegetations with strong root system, such as locally available kudzu (Pueraria lobata), having a low demand for soil moisture, soil fertility and are locally available is recommended to be planted on the sides of gullies along with the construction of check dams at the required interval. Siltation of the wetland bottom is becoming a serious problem leading to the degeneration of the wetland. The sediment should be trapped in the catchment areas through afforestation and by constructing check dams parallel to the shoreline. This will help in accumulation of silt in the littoral zones. Hill cutting and quarry operation in the wetland catchment should be stopped immediately. In addition, contour cultivation should be practiced instead of the currently followed up and down cultivation in the wetland catchment.

It is a highly visible form of soil erosion that affects soil productivity, restricts the land use and can threaten roads, fences, buildings, etc. Gullies are relatively steep-sided watercourses, which cause ephemeral flows during monsoon. Soil eroded from the gullied area can cause siltation of lakes, wetlands, road culverts, dams, reservoirs, etc. Suspended sediments, which may have attached nutrients and pesticides, can adversely affect the water quality. These fines, colloidal clay particles remain in suspension and may clog groundwater aquifers, pollute watercourses and affect aquatic life.

Conservation measures

Based on the study, following conservation measures are suggested.

1. The chemical fertilizers, pesticides etc. in agriculture in the fringe and catchment areas of the wetland should be judicially used. The STP and effluent treatment plants of suitable capacity should be installed in the area to treat sewage and industrial effluents and led the treated water towards the wetland.
2. The wetland should be suitably dredged for the removal of aquatic weeds and silt on a regular basis in order to provide better environment for fish and other aquatic life.
3. The sediment should be trapped in the catchment areas through afforestation and by constructing check dams parallel to the shoreline. Hill cutting and quarry operation in the wetland catchment should be banned immediately.
4. The contour cultivation should be encouraged instead of the currently followed up and down cultivation in the wetland catchment.
5. To check further gullying process, vegetations with strong root system, like kudzu (*Pueraria lobata*) should be planted on the sides of gullies along with the construction of check dams at the required interval so as to check the gullying process.
6. Wetland boundary should be clearly demarcated so as to check the gullying process starting from the northern and eastern parts of the wetland. Indiscriminate construction of engineering structures across wetland for different purposes should be discouraged.
7. The organization of awareness programme and participation of public should form the major conservation measure. The role of the non-government organizations (NGOs) and other vol-

untary agencies is very important in generating public awareness for the conservation of the wetlands.

CONCLUSIONS

The NSF-WQI of the wetland on the basis of water quality analysis of the data collected for year 2005 and 2006 and its comparison with base year 1989 index shows the continuous worsening of water quality. Besides, the erosion and gully erosion were found as the major problem contributing to the ill health of the water body. Conservation measures are suggested for regaining the status of the wetland.

REFERENCES

[1] R.K.Trivedi, P.K.Goel; 'Chemical and Biological Methods for Water Pollution Studies', Environmental Publications, Karad, **(1986)**.

[2] E.G.Bolen, L.M.Smith, Jr. H.L.Schramm; Bioscience, **39**, 615-623 **(1989)**.

[3] N.L.Christensen, R.B.Wilbur, J.S.McLean; Soil-Vegetation Correlations in the Pocosins of Croatan National Forest, North Carolina. U.S.Fish and Wildlife Service, Fort Collins, CO., **(1988)**.

[4] K.Firehock, et. al.; 'Handbook for Wetlands Conservation and Sustainability', Z.Hoskins (Ed.). Rock Creek Publishing Group, Bethesda, MD, **(1998)**.

[5] R.Rajnikant, T.V.Ramachandra; 'Wetlands-Nature's Neglected Lot', Karnataka Environment Research Foundation, Issue 4, at http: // wgbis .ces .iisc .ernet . in /energy/finance/New/cover.html, **(2002)**.

[6] Limgis; 'Restoration and Management Strategies for Wetlands' (b), at http://ces.iisc.ernet.in/energy/monograph1/Casepage3.html, **(2001)**.

[7] D.K.Baruah; 'Studies on Algae as Biomonitors of Pollution in some Water Bodies of Greater Guwahati', PhD Thesis, Guwahati University, India, **(1995)**.

[8] APHA-AWWA-WPCF; 'Standard Methods for the Examination of Water and Wastewater', 20th Ed., **(1998)**.

[9] BIS: 10500, 'Indian Standard Drinking Water Specification', New Delhi, **(1991)**.

[10] Metcalf Eddy; 'Wastewater Engineering- Treatment, Disposal and Reuse (Third Edition)', Tata McGraw-Hill Publishing Company Ltd., New Delhi, **(1995)**.

[11] 'National Sanitation Water Quality Index' at www.water-research.net/watershed/temperature and www.water-research.net/waterqualindex/waterqualityindex.