Assessment and Management of Non-Point Water Pollution Sources of Laxmi Taal, Jhansi (U.p.)

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ABSTRACT

Present study has been undertaken to analyze Physico-chemical and bacteriological characteristics of Laxmi Taal. Laxmi Taal, a historical site, located in Jhansi city, Bundelkhand Region, currently is being used as a disposal site for municipal and agricultural waste. Sample collection was done seasonally in 2006 from 8 sampling sites to get the variation in the sewage disposal and characteristics of waste water to get the exact source of their origin. The results revealed that the water of Laxmi Taal is highly polluted due to high total alkalinity; Free CO2, total hardness, suspended solids; pH, Chloride, turbidity, COD, BOD and low level of dissolve oxygen. Biodiversity status of this water body also monitored during this project and reported this site as supportive site for biodiversity habitat if properly managed by government and social activists. Basis on these results recommendation need to be consider at very alarming rate as suggested in this study.

INTRODUCTION

Water pollution is a serious problem in the Global context and pose worldwide disturbance. Pollution is a vexing problem in countries where the population is growing rapidly, development demands are great, and governments have other investment priorities (*Aliaoue*, 1998). Today many natural water natural water bodies in India receive million of liters of wastewater and agricultural runoff, with different concentration of pollutants in varying forms. Many factors such as deforestation, excessive erosion, introduction of exotic species, domestic and industrial waste disposal and agricultural runoff influence water quality within a reservoir (*Chaves et al,* and 2003). Jhansi the gateway of Bundelkhand is an important destination of Bundelkhans Region. Its greatest claim to fame is its fiery queen "Rani Laxmi Bai who led forces against British in 1857, scarified her life to the cause of Indian Independence. The area of Jhansi city within municipal limits is approximately 35.22 sq km. The important places for visitors at Jhansi are Jhansi fort, Government Museum, Rani Mahal Government Auditorium, Mukta Kashi Manch, Goddess Maha Laxmi Temple, Ram Raja Temple, Mahadeo Temple, Laxmi Taal, Narayan Bagh, Burwa Sagar. Present study based on the water quality status of Laxmi Taal which is subjected to serve pollution stress from the urban community.

MATERIALS AND METHODS

Study Area

Laxmi Taal is a beautiful water tank outside the city wall in the direction of Kaimasan Hill. Laxmi Taal covers an area of 32.52 hectare with an average depth of 2.5 meter. It lies between longitude of 78º 37´ E and 25 º 7´ N of latitude. Laxmi Taal has a catchment area of 2370 hectare having storm water intensity of nearly 0.75 /hour/acre of flood rain. Common biological growth in this Taal includes *Echhornia crassipes* (water hyacinth), *Spirodela* sps. (Duck weed), *Ipomea auatica* (water spinach), *Azolla pinnata*, *Typha angustifolia* (Cattail), *Trapha natans* (water caltrop), *Cyperus rotundus*, *Cyperus alopecuroides*. This area is spotted as an birding site due to the presence of Naryan Bagh on the opposite side of Laxmi Taal. Cattle egret, Little egret, Paddy bird or Pond heron, Brahminy Duck, Spotbill or Grey Duck, Common Pariha Kite, Shovaller, Little Brown Dove, Ring Dove, Blue rock Pegion, Koel, Crow Pheasant, House swift, Common Swallow, Black Drongo, Small Minivet, Indian Robin, Lark Sps, Mayna, Crow etc are frequently spotted around this Taal and nearby area.

It is rain feed tank, but since a few years, it is being used as a disposal site for municipal and agricultural waste. Thickly polluted area of the city is finding way into Laxmi Taal through 6 Nalas, Laxmi gate Nala, Badagaon Nala, Bagla Nala, Kasai mandi Nala, Kubarau Nala, Joshiygana Nala. These Nalas discharge sludge collected from 19 localities into the pond. The water of the pond is highly polluted. The flow rate form all selected six Nalas representing the amount of the discharged waste water from various sources into Laxmi Taal as in table 1:

Table 1: Flow Rate of discharged material through 6 Nalas into Laxmi Taal (liter /Sec)

Sr. No	Nalas	FlowLps (Liter/Sec.)
1	Kuberau Nala	32.2
2	Kasai Mandi Nala	53.7
3	Laxmigate Nala	40
4	Joshiyana Nala	14.5
5	Bangla Ghat Nala	22.3
6	Budagaon Nala	28.6

Source: Jal Nigam Jhansi, 2006

Selection of the Sampling Sites

Water samples were collected separately for determination of physico-chemical and bacteriological characteristics from 8 sampling stations, Laxmi gate Nala, Badagaon Nala, Bagla Nala, Kasai mandi Nala, Kubarau Nala, Joshiygana Nala, laxmi taal inside and Narayan Bagh Narayan Bagh Outlet in May (Pre monsoon) and July (Peak Monsoon) 2006 (sites mentioned in digram). Temperature and pH were measured at the collection sites. The samples were preserved for other parameters in accordance with the standard methods (APHA, 1989).

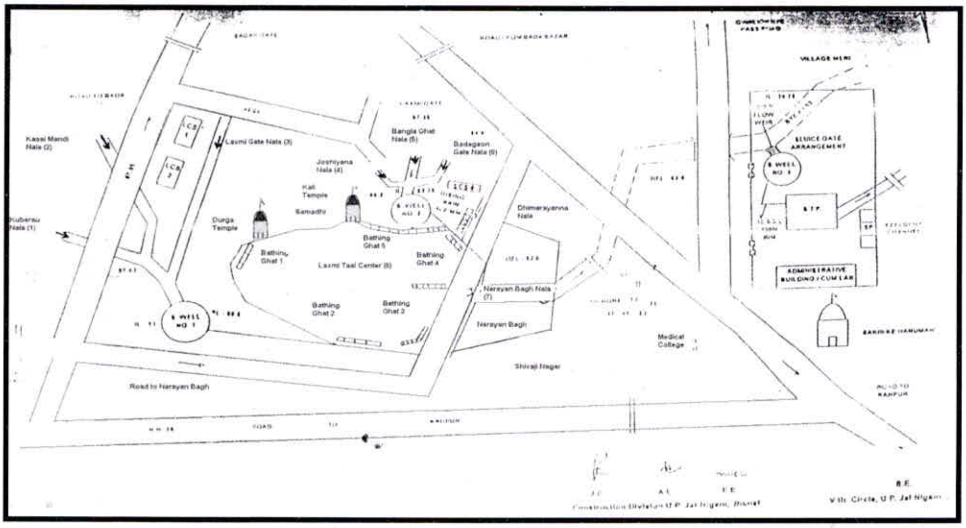

Fig. 1 : Map of Laxmi Taal representing 6 discharging and 8 sampling sites selected for this study

RESULT AND DISSCUSSION

Eight samples of Laxmi gate Nala, Badagaon Nala, Bagla Nala, Kasai mandi Nala, Kubarau Nala, Joshiygana Nala, laxmi taal inside and Narayan Bagh Outlet respectively were collected and studied on monthly bases, May to July. The months were grouped as pre monsoon (May) and peak monsoon (July). The results of the water quality analysis are presented in Table 2 and 3.Temperature is one of the most important ecological factors, which controls the physiological behavior and distribution of organism. *Jain* et al. (1996) has observed diurnal variations temperature. In the present study, the pattern of temperature function was more or less similar in all the 8 sampling stations. The temperature of the ground water depends on the season and on the temperature of the ground with which it is in contact. The temperature of Laxmi Taal varied from 42.5^{0}C to 45.5^{0}C in May and 26^{0}C to 29^{0}C in July at all station. The variation in temperature was significant between the summer and rainy season. Extremes of pH hinder of the survival of living organisms. The balance in the ecosystem is maintained when the pH ranges

Table 2: Physico-chemical Characteristics of the eight Sampling sites in Pre-monsoon season (May).

Sr. No	Characteristics	Kuberau Nala	Kasai Nala	Laxmi Gate Nala	Joshiyana Nala	Bangla Ghat Nala	Budagaon Nala	Outlet Narayan Bagh	Laxmi Taal Inside
1	Temperature (ºC)	42.5	42.9	43.3	43.5	43.8	44.2	45.3	45.5
2	Colour	L Y	LB	LY	LY	Muddy	LB	LB	LY
3	Odour	Foul	Foul	Foul	Foul	Foul	Objectionable	Foul	Foul
4	pH	9.83	9.95	8.20	8.75	7.2	7.5	8.4	8.52
5	Conductivity µmhos/cm	61.3	82.4	75.4	104	129	122	81.6	60.6
6	Turbidity (NTU)	13.4	31.7	24.9	53	71	69	29.9	11.8
7	TSS mg/L	100	110	125	142	167	158	68	75
8	TDS mg/L	590	600	625	647	673	664	218	225
9	TS mg/L	690	710	750	789	840	817	286	300
10	Total Hardness mg/L	212	250	206	240	494	560	384	250
11	Ca++ Hardness mg/L	38.48	39.30	26.47	24.06	54.54	56.14	85.81	44.11
12	Mg++ Hardness mg/L	76.5	100.24	92.33	118.71	236.1	276.99	112.11	92.33
13	Alkalinity mg/L	560	600	570	830	860	850	650	540
14	Chloride mg/L	142	243.2	158	237.9	362.1	408.3	213.35	168.63
15	Free CO2 mg/L	17.6	39.6	30.8	44	26.4	30.8	8.8	13.2
16	DO mg/L	Nil	Nil	Nil	4.5	5.4	Nil	5.2	.81
17	COD mg/L	400	528	784	704	816	656	64	208
18	BOD mg/L	52	64	96	85	108	82	7	25
19	Sulphate mg/L	78.72	80.73	71.28	63.33	80.53	67.19	29.71	61.44

Table 3: Physico-chemical Characteristics of the eight Sampling sites during Peak-monsoon season (July)

Sr. No	Characteristics	Kuberau Nala	Kasai Nala	Laxmi Gate Nala	Joshiyana Nala	Bangla Ghat Nala	Budagaon Nala	Outlet Narayan Bagh	Lami Taal Inside
1	Temperature (°C)	26.0	26.3	26.5	27	27.4	28.0	28.7	29.0
2	Colour	LY	LB	LB	Muddy	LB	Muddy	LY	LY
3	Odour	Foul	Foul	Foul	Foul	Foul	Foul	Foul	Foul
4	pH	8.21	8.38	7.92	8.16	7.9	7.2	7.3	7.54
5	Conductivity µmhos/cm	49.6	53.8	52.3	83.2	106.3	96.2	75.3	81.7
6	Turbidity (NTU)	8.3	9.7	8.9	30.2	53.6	38.3	24.7	29.5
7	TSS mg/L	178	183	209	175	225	135	84	112
8	TDS mg/L	778	675	1197	653	911	799	464	781
9	TS mg/L	956	858	1406	828	1136	934	548	893
10	Total Hardness mg/L	92	110	136	128	238	140	138	150
11	Ca++ Hardness mg/L	12.83	9.62	8.82	9.62	14.43	39.28	11.22	10.42
12	Mg++ Hardness mg/L	39.57	56.72	75.18	68.59	133.22	93.65	72.55	81.78
13	Alkalinity mg/L	380	400	500	560	650	620	360	410
14	Chloride mg/L	108.28	122.48	118.93	117.5	307.08	232.53	157.98	131.35
15	Free CO2 mg/L	22.0	22.3	48.4	30.8	23.2	17.6	13.2	17.8
16	DO mg/L	.87	.86	2.62	3.49	6.11	7.86	2.62	4.37
17	COD mg/L	560	640	440	560	293.3	346.7	280	453
18	BOD mg/L	69	78	57	67	30	38	28	46
19	Sulphate mg/L	55.68	34.56	21.12	29.03	78.12	67.27	20.45	43.12

between 5.5 and 8.5. During the present study, pH value ranged from 7.5 to 11.0. It was 7.0 at Budgaon Nala and 11.0 at Joshiyana Nala. This is not accordance at some sites of the samples with earlier reported by *Wetzel* (1972), who reported that the value of pH ranges from 8.0 to 9.0 units, in Indian water. In peak monsoon pH found from 7.22 to 8.38. So the water sample at some sites appears to be highly polluted in pre-monsoon and above the desirable limits (7.0 to 8.5). Colors of the various water samples varied from light yellow to light brownish in both seasons. The conductivity of the water depends upon the concentration of the ions and its nutrients status and variation and dissolve solid contents are indicated by conductivity measurements. The conductivity value of the pre monsoon ranges from 60.6 µmhos/cm to 129 µmhos/cm and in peak monsoon value ranges from 149.6 µmhos/cm to 106.3 µmhos/cm.

The suspended particle soil, silt decomposed or un-decomposed organic matter, total dissolve solids as well as microscopic organisms etc are the main source of turbidity in water, which always interferes in the penetration of the light. The turbidity value ranged from 13.4 NTU to 53.6 NTU in July at every sample site. The value of the turbidity is higher than the permissible limit (5 to 25 NTU). The disposal of both suspended and dissolved solids leads to sedimentation (*Saxena*, 1998). The settled solids include inorganic and un-dissolved solids, which settle to the bottom of the ponds causing silt deposition of the water bodies. The removal of total solids is 25% to 53% in the course of treatment. The TDS recorded in May at sampling sites ranged from 218 mg/L to 673 mg/L and in July it ranged upto 464 mg/L to 1197 mg/L. Total suspended solids ranged from 75 mg/L to 167 mg/L in May and 84 mg/L to 225 mg/L in July. The total solids value ranged from 286 mg/L to 840 mg/L in May and 548 mg/L to 1406 mg/L in July. All the sampling stations values are very high from the desirable limits and permissible limit (500 mg/L).The hardness of the water reflexes the nature of geological formation with, which the water is in contact. The total hardness of the water samples varied from 212 mg/L to 560 mg/L in pre-monsoon and 92 mg/L to 238 mg/L during peak-monsoon. According to *Kannan* (1991) water with their hardness value less than 60 mg/L is soft, hence the waters of Nalas and Inlet and Outlet cannot be regarded as soft water. *Seghal*, (1989) reported low level of total hardness in the pong reservoir. Mg^{++} hardness of Nalas, outlet and inlet ranged from 76.5 mg/L to 276.99 mg/L in May and 39.57 mg/L to 133.22 mg/L in July. The value of Mg^{++} hardness are not under standards limit (24.28 mg/L). Ca^{++} hardness of Nalas, Outlet and inside water ranged from 24.06 mg/L to 85.81 mg/L in May and 8.82 mg/L to 39.28 mg/L in July and in May at some stations are above the permissible limit (80.10 mg/L).

Total alkalinity is a measure of bicarbonates, carbonates and hydrates. The alkalinity of the Nalas, outlet and inside water was found higher than the hardness values. It ranged from 540 mg/L to 860 mg/L in May and 360 mg/L to 650 mg/L in July. The value of alkalinity was higher than the desirable limit (200 mg/L). Chloride concentration indicates the presence of organic waste, primarily of animal origin. Chloride concentration varied found 142 mg/L to 408 mg/L in May and 108.28 mg/L to 307.08 mg/L in July. Chloride is the common anion found in water and sewage. Chloride concentration was found relatively high in the month of May at all stations. The value of chloride is higher than the desirable limit (250 mg/L) at some sampling stations but all are under the permissible limit (1000 mg/L). In the present investigation, the values of CO_2 vary from 13.2 mg/L to 48.4 mg/L in May and 13.2 mg/L to 44.0 mg/L in July and are not within the desirable limits (6 mg/L). *Jain* et al., (1996) estimated nil to 5.0 mg/L of CO_2 at Halali reservoir. Similarly, *Mathew* (1978) observed an inverse relationship between CO_2 and dissolve oxygen in Govind Sagar. The free CO_2 also recorded a significantly positive correlation with total alkalinity. *Cole* (1975) noted that free CO_2 supply rarely limits the growth of phytoplankton. Alternately the photosynthetic activity of plankton adopts by utilizing bicarbonates as a source of carbon. During the period of investigation the minimum value of DO was recorded 0.82 mg/L at Laxmi Taal Inside, while the maximum value of DO was recorded 5.4 mg/L at Bangla Ghat Nala in May and in July the DO value ranged from 0.87 mg/L to 7.86 mg/L. The lowest value is observed at discharge point where mixing of sewage occurs immediately. It has increased near outfall due to photosynthetic activity. The DO in the sewage is nil at some sample stations, indicating its septic nature and wherever the DO recorded was less then desirable limit (6 mg/L) except at Budagaon Nala (7.86 mg/L).

The BOD value at sampling stations was in the range of 7 mg/L to 108 mg/L in May and 28 mg/L. However, all the samples showed COD values above than the permissible limit. The value of COD recorded 64 mg/L to 816 mg/L in May and 280 mg/L to 640 mg/L in July. The Narayan Bagh Outlet sample showed the COD value (64 mg/L) within the permissible limit. The COD determines the chemical oxidisable organic matter present in sewage (*Garg* 1998). The present study is evidenced to the maximum concentration of sulphates in the month of May (29.71 mg/L to 80.73 mg/L) and July (21.12 mg/L to 78.12 mg/L), all the values were within the permissible limit (400 mg/L). The concentration of sulfate increases due to the activity of biodegradation (*Munawar* 1970), where sulphate is associated with an increased level of pollution. Dilution and utilization of sulphate by aquatic plants gradually brought sown sulphate concentration in monsoon. Faecal pollution is a major concern for many water bodies where it can originate from human sources and non- human sources. Its impact can degrade water quality and restrict its use for drinking and recreational activities. Laxmi Taal received a variety of sources, including humans, cattle and wildlife. The faecal coliforms *Escherichia coli* has been used as an indicator of human entrees pathogen for many years (*Goldric*, 1996). However, it is now well established that E. coli is not limited to human but also exist in the intestine of many other warm blooded animals (*Orskov* and *Orskov* , 1981).

Present findings indicate that the water of Laxmi Taal is highly polluted due to high total alkalinity, free CO_2, chloride, total hardness, TDS, TSS, TS, pH, turbidity, COD, BOD, faecal pollution and low level of dissolve oxygen. Due to the continuous flow of municipal sewage from urbanized Jhansi city, Laxmi Taal overflowing throughout the year, thus changing the characteristics of the water quality. With such substantial quantities of pollutants released in the water body through various Nalas as mentioned above, the biotic survival in this water body is becoming difficult.

RECOMMENDATIONS AND SUGGESTIONS

Laxmi Taal area can be developed as a recreational spot to attract tourism activities through supportive and suggested module. Restoration strategy should develop in collaboration with government, stakeholders, activist and scientific and social research. Future management and development of this historical place can be helpful to set up an example of successful planning and policies implementation.

The management structure, social and political relationships within the Strategic Model for water resources management should be shaped by common and intellectual experiences. Useful activities and tools to support decision-making in this area could include:

1. Landscape inventories;
2. Representing examples of successful integrated water conservation and restoration and analyzing their implementation mechanisms and impacts at various levels;
3. Reviewing/adapting methods and tools to identify and measure the water quality and seasonal changes that are contributing by various human factors.
4. Monitoring and evaluating the implementation, effectiveness and impact of developmental activities and policies;
5. Designing and implementing institutional mechanisms to enhance coordination among sectoral policies dealing with water resources conservation issues.

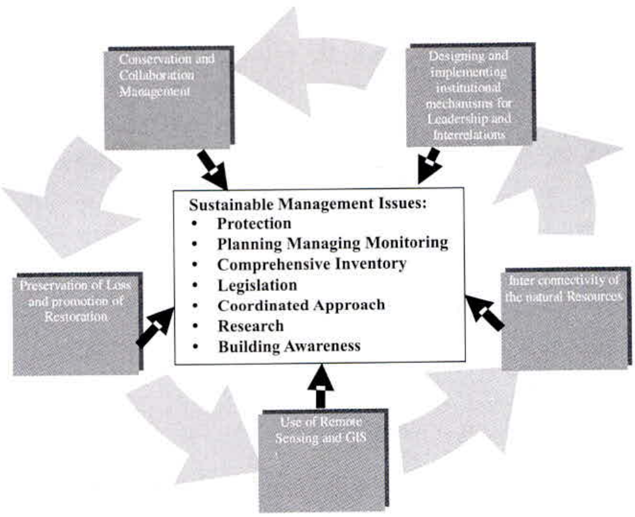

Fig. 2 : Supportive Model for Water Resources Conservation

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