Restoration of the Traditional Small Water Bodies in Braj

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ABSTRACT

The Braj in India has a very old heritage of forests, hills and small water bodies. The water bodies known as kunds were important sources of fresh water in the area and used for various purposes but due to prolonged negligence and lack of maintenance, most of them have now become silted up. The kunds have been classified into three categories according to their present water level, siltation status, structures, etc. Poor category kunds should be taken immediate attention. The present study aims at understanding the reasons for deterioration of the kunds and making some technical suggestions for revival of these kunds.

KEYWORDS : *Braj, Kunds, Water bodies, Restoration Techniques.*

INTRODUCTION

The Braj is a culturally vibrant region in India lying in close vicinity of Taj Mahal, Agra. It has no clearly defined political boundary but it is well known for its rich culture, festivity and an ancient heritage of forests, hills and man-made small water bodies. It is said that Lord Krishna (God in Hindu mythology) has spent his childhood and adolescence in Braj and therefore, it is an important place of Hindu pilgrimage. The area was once covered with 137 sacred groves which have now turned into tropical thorny scrubs. During the growing human occupancy in the region, gradual clearing of the natural vegetation has continued. Today there exists a few small patches of forests in the areas of religious importance like "Kokilavan", "Gahvarvan", etc. due to religious ban on cutting on trees. Mathura district which alone covers about 71 % of the total Braj has a forest cover of 61 km^2 at present including moderately dense and open forest which is only 1.83 % of the total geographical area of the district (FSI, 2005). The hills in the area are the extension of the Aravalli range which lies on the border of Rajasthan state. The average height of the hills is 261 m above mean sea level and their stones are sandy. Govardhan Parvat (Govardhan), Vishnu and Brahma Parvat (Barsana), Mahadev Pahar (Nandgaon) and Charan Pahari (Bathain Khurd) are the main hills in the area (Prasad, 2000). Due to the illegal mining in the Braj hills particularly in the Bolkhera region in Rajasthan, the 18000 acres of hilly terrain which used to be the grazing fields of cattle, have now turned into barren lands posing a severe threat to ecology and environment (Misra, 2004).

The importance of the traditional sources of water like Talabs, Bawri, Tals, etc. in the development and sustenance of an area is well established. These conventional sources of water have played an important role in sustaining human and animal life for ages. The Braj area is no exception. The traditional small water bodies in Braj are commonly known as kunds. Once in Braj, there were 1000 kunds which used to be the source of fresh water. The water was used for multifarious purposes like irrigated agriculture, domestic uses, drinking water for cattle, bathing etc. Due to rapid urbanization, lack of maintenance and prolonged negligence in the last 50-100 years, most of the kunds today have become silted up and are nearing extinction. The impending crisis for fresh water has forced the planners and policy makers to take cognizance of these traditional water bodies. They have a special bearing on the ecology and culture of the region where they evolved. Thus, there is an urgent need of taking necessary measures to restore the kunds for the welfare of the mankind at large.

The kunds in Braj were built by the ancient kings or leaders of the tribes through the rural people during the 5th-15th century. They were not only planned and constructed by the local people but also managed by them locally. Almost every village had one or more such man-made water structures. One of the most ingenious technologies in Braj has been the creation of these small water bodies. Ingenious because the water bodies were built in lower and mid-slope positions so that they can capture runoff resulting from the monsoon rains which have a wide diversity in distribution. In order to protect the water bodies, pucca ghats were built using sand, stones, lime, etc. to make it sufficiently strong. The maintenance of ghats is also important otherwise huge runoff generating from heavy downpour may wash away the structure. In order to prevent the ghats from breakage, spillways were built at a certain height so that water can be stored upto an optimum limit for use during the rest of the year without any damage to the water bodies and excess water is drained off. Due to erosion by the storm water, silts get deposited in the water bodies every year. Removal of silts requires huge man power and time. But, people used to accept the mammoth task as a blessing rather than a problem. They fixed the time for silt removal following the logic that minimum depth of water should be there during the desilting operation. Farmers used to dig the silts, put them in carts and spread them into the crop fields to make the land fertile. In return they had to pay some cash or some portion of crops grown to the village fund, which was further used for the repairing work of the structures (ABKHT, 2004). But, the periodical maintenance of the water bodies, cleaning and minor repairs of the structures has been gradually neglected over a period of time. This has led to the deterioration of the ghats, siltation of the water bodies, weed infestation resulting in inadequate storage and wastage of water through seepage. Some water bodies have become extinct due to urbanization and encroachments. Restoration of these existing small scale water resources is much more cost effective than developing new water resources since suitable sites for forming new water bodies are not available with the increasing pressure on land for various purposes. In this paper an effort has been made to focus on the hydrologic condition of the kunds in Braj.

AREAL EXTENT

The traditionally called 'Braj' area which is associated with the legend of Sri Radha-Krishna, one of the most celebrated divine couples in Hindu mythology. Braj spans across three States of India; Mathura district of Uttar Pradesh (U.P.), portions of Bharatpur district of Rajasthan and Palwal district of Haryana. It falls under the golden triangle of Delhi-Agra-Jaipur. This area lies between 27° 19′ N to 27° 58′ N latitude and 77° 09′ E to 77° 51′ E longitude. Braj has no clearly defined political boundary but the region is well demarcated culturally. The boundary shown in Fig. 1 is based on the *Radharani Braj Yatra* Map (Source: TBF, 2006). Covering an area of about 3712 km^2, Braj can be divided into two distinct units. The eastern part of the river Yamuna includes places like Gokul, Baldeo, Mat and Naujhil of Mathura district. The western part of the Yamuna is much larger than the east and encompasses Vrindavan, Govardhan, Chhata, Kosi, Barsana and Nandgaon of Mathura; Kaman and Dig Tehsil of Bharatpur district in Rajasthan and Hodal Tehsil of Palwal district in Haryana.

GEOLOGY

The region mainly lies in the Indo-Gangetic plain of almost uniform topography. Except the hilly tracts of Rajasthan, the remaining area comes under Indo-Gangetic alluvium of

Quarternary age of variable thickness ranging between 200 - 300 m. The lithological logs of tube wells to a depth of 30 m. inventoried in different parts of Mathura district show that the fluvial sediments constitute of different grades of sand and clay with Kankar in varying proportion. Kankar is a local name of calcareous concentrations of nodular limestone. It is found on both sides of river Yamuna. Two principal aquifers have been encountered over the area. The first one lies between 30-80 m and second one between 125-175 m below the ground. Deeper aquifers contain saline/brackish ground water. The fresh ground water potential of the area is limited. The ground water in shallow aquifer occurs under unconfined state while in deeper zone it lies under semi-confined to confined state. The depth to water table over the district lies between 5-10 m below ground during pre monsoon season, with an average rise ranging between 0.5-1.0 m during post monsoon (CGWB, 2003).

CLIMATE

The area experiences sub humid to dry climate with a mean annual rainfall of 650 mm. There are three distinct seasons namely summer, monsoon and winter. The bulk of annual rainfall occurs through south-western monsoon during the period of July to September (IMD, 2005). August is the wettest month with the maximum number of rainy days. Summers are quite warm with average temperature of 41°C which occasionally shoot upto 45°C. The maximum daily duration of bright sunshine hours is 10.6 h which is observed during May month. The month of January is the coldest when the temperature goes down to 10°C or even less occasionally. Wind velocity is pretty high over the year with average annual value of 6.3 kmph and going as high as 8.5 kmph during April.

WATER BODIES

There are about 300 kunds existing today. Out of them, 108 kunds have been surveyed by The Braj Foundation, U.P., India which is a voluntary organization working for the all round development of Braj. The survey includes the geographic location, size, water depth, siltation status etc. of the kunds. The kunds have been identified in the Survey of India (SOI) topographical maps (1:50,000 scale) no. 54E/2, 54E/3, 54E/6, 54E/7, 54E/10, 54E/11, 54E/14 and 54E/15. One scene of IRS-P6 L4MX satellite imagery obtained from NRSA, Hyderabad which covers a small portion of Braj shows some of the kunds as shown in Fig.2. Based on the survey, the kunds have been classified into three categories, viz., poor, moderate and good according to their water level, siltation status and condition of the boundaries (ghats), as given in Table 1, 2 & 3. Kunds are listed in alphabetical order followed by the name of the village in which they are situated.

Table 1 : Kunds under poor category (Source: TBF, 2006)

Name	Longitude (E)	Latitude (N)	Area (m^2)	Perimeter (m)	Water level	Structure/ ghats	Condition
Aajhai Khurd, Ajhai	77.582	27.604	21127.0	623.0	Poor	Earthen	Poor/ algal bloom
Akroor Kund, Chhata	77.688	27.569	18088.3	585.8	Dry	1 old ghat	Poor/ silted up
Anand Kund, Habibpur	77.801	27.415	13454.3	506.6	Poor	4 ghats	Poor/siltation high
Asheswar Kund, Nandgaon	77.401	27.716	1087.5	136.6	Poor	Earthen	Poor/algal bloom
Balbhadra Kund, Raal	77.567	27.560	9797.0	467.5	Poor	1 old ghat	Poor
Baldev Kund, Kamai	77.431	27.630	8320.3	368.8	Poor	5 old ghats	Poor/garbage dump
Baldev Kund, Kunjera	77.481	27.552	3919.0	277.4	Poor	2 old ghats	Poor/ siltation high

Name	Longitude (E)	Latitude (N)	Area (m^2)	Perimeter (m)	Water level	Structure/ ghats	Condition
Banmali Kund, Akbarpur	77.565	27.645	33043.0	721.4	Dry	Old broken ghats	Poor/silted up
Bhanukhar Kund, Barsana	77.382	27.648	5135.1	277.2	Dry	Earthen	Poor/flat field
Bihariji Kund, Chhata	77.582	27.621	4336.5	263.4	Poor	No ghats/boundaries	Poor/silted up
Bishori Kund, Bijwari	77.417	27.699	3233.5	236.3	Poor	1 old ghat	Poor/shallow water
Brahma Kund, Vrindavan	77.701	27.583	1206.6	139.2	Dry	Broken ghats	Poor/silted up
Brahma Kund, Chaumuha	77.584	27.625	1628.2	162.6	Dry	No ghats/boundaries	Poor/silted up
Chandra Kund, Chhata	77.508	27.720	9983.0	434.7	Poor	No ghats/boundaries	Poor/almost silted up
Chandra Sarover, Chaumuha	77.587	27.623	25536.0	611.5	Poor	No ghats	Poor/almost dry
Charan Ganga, Kosi	77.369	27.788	20681.6	586.8	Poor	1 old broken ghat	Poor
Chetna Kund, Kamar	77.358	27.834	6006.3	309.4	Dry	No ghats/boundaries	Poor/almost silted up
Chir Kund, Jao	77.413	27.728	3857.0	251.7	Dry	Ghats ruined state	Poor/covered with water-lilies
Dauji Kiund, Jakhangaon	77.523	27.510	8694.4	372.1	Poor	No ghats/boundaries	Poor/almost silted up
Dharma Kund, Jao	77.413	27.735	3223.9	235.4	Poor	2 old ghats	Poor/garbage dump
Girirajji Kund, Hathiya	77.375	27.599	10660.7	484.1	Poor	1 old ghat	Poor/used by cattle
Golok Kund, Ranhera	77.580	27.748	22443.5	611.7	Poor	No ghats/boundaries	Poor/siltation high
Gopal Kund, Kamai	77.432	27.630	17899.0	638.0	Poor	1 old ghat	Poor/algae infestation
Gopal Kund, Paigaon	77.528	27.780	28751.8	718.8	Poor	Pucca ghat 1 side	Poor/ almost silted up
Govind Kund, Vrindavan	77.699	27.574	2810.0	226.0	Dry	4 ghats	Poor/silted up
Gyan Kund, Sehi	77.645	27.663	4992.2	296.6	Dry	No ghats/boundaries	Poor/dry
Gyan Kund, Vachhgaon	77.467	27.396	1596.7	160.4	Poor	2 old ghats	Poor/almost dry
Hansa Kund, Palso	77.417	27.584	11390.4	438.0	Poor	No boundaries/ ghats	Poor/muddy water
Hanuman Kund, Naugaon	77.609	27.707	8458.0	368.5	Dry	No boundaries/ ghats	Poor/dry
Jai Kund, Jait	77.610	27.585	25171.0	603.5	Poor	No ghats/boundaries	Poor/restoration going on
Kamal Kund, Gokul	77.720	27.437	4561.9	270.9	Dry	1 old ghat	Poor/ silted up
Kameswari Kund, Kamar	77.340	27.812	7995.2	357.6	Poor	2 broken ghats	Poor/ siltation high
Kanker Kund, Kamar	77.340	27.816	28030.4	713.7	Poor	No boundaries/ ghats	Poor/silt deposited
Kathamkhandi Kund, Nandgaon	77.401	27.719	990.5	148.5	Dry	No ghat	Flat field
Kishori Kund, Jao	77.419	27.670	8966.2	404.2	Poor	1 old ghat	Poor/siltation high
Krishna Kund, Bharna Khurd	77.466	27.597	5887.4	309.8	Poor	2 old ghats	Poor/silt deposition
Krishna Kund, Rahera	77.467	27.648	7559.1	347.5	Poor	1 old & broken ghat	Poor/ silt deposition

Name	Longitude (E)	Latitude (N)	Area (m^2)	Perimeter (m)	Water level	Structure/ ghats	Condition
Krishna Kund, Sanket	77.380	27.679	8649.8	480.8	Poor	Earthen	Poor/high algal bloom
Lohvan Kund, Lohban	77.728	27.512	6186.0	288.6	Dry	7 old ghats	Poor/silted up
Ksheersagar, Sihana	77.546	27.627	55711.0	1348.7	Poor	No boundaries/ ghats	Poor/muddy water
Lalita Kund, Nandgaon	77.390	27.711	8959.9	384.1	Poor	1 old ghat	Poor/deposition of silt
Laxman Kund, Raya	77.789	27.556	7711.9	351.5	Poor	No ghats	Poor/muddy water
Madhusudan Kund, Nandgaon	77.385	27.706	12657.7	538.6	Moderate	2 old ghats	Poor/high algal bloom
Maheswari Kund, Hathiya	77.377	27.599	9818.9	596.5	Poor	1 old & broken ghat	Poor/silted up
Mandeura Kund, Dahrauli	77.374	27.832	4888.1	279.7	Poor	No ghats	Poor/silted up
Mansa Kund, Pasauli	77.414	27.536	17911	544.2	Poor	1 old ghat	Poor/silted up
Mohan Kund, Nandgaon	77.396	27.704	1711.1	189.6	Poor	12 ghats scattered	Poor/silted up
Moti Kund, Nandgaon	77.382	27.719	8819	384.2	Poor	Earthen	Poor/ water hyacinth
Pali Kund, Debiya	77.449	27.440	5240.3	289.1	Poor	2 old ghats	Poor/siltation high
Palso Kund, Palso	77.419	27.569	14924	567.5	Poor	Broken boundary	Poor
Panda Kund, Pali	77.460	27.568	4536.2	269.1	Poor	No ghats/boundaries	Poor/infested by aquatic weeds
Parshuram Kund, Jatwari	77.577	27.775	33524.8	828.8	Poor	1 old ghat	Poor/siltation high
Phulwari Kund, Nandgaon	77.378	27.726	9534.0	361.5	Poor	Earthen	Poor
Pimani Kund, Mahrauli	77.384	27.559	7815.0	365.7	Moderate	2 old ghats	Poor
Piripokher, Iklahera	77.349	27.505	5261.3	338.5	Dry	1 old ghat	Poor/silted up
Prem Sarovar, Gokul	77.724	27.440	2654.8	206.8	Dry	No ghats/boundaries	Poor/dry
Priya Kund, Barsana	77.377	27.653	5979.0	310.0	Poor	Earthen	Poor/silted up
Priya Kund, Kamai	77.431	27.635	6732.0	336.6	Dry	No ghats/boundaries	Poor/silted up
Rabar Kund, Raal	77.563	27.561	15523.0	630.7	High	Poor/marshy water	Poor
Radhamohan Kund, Chaumuha	77.581	27.629	18270.0	645.8	Almost dry	2 ghats/ no boundaries	Poor
Rewati Kund, Jakhangaon	77.542	27.517	9235.0	418.7	Poor	No ghats	Poor/almost silted up
Rudra Kund, Rankoli	77.336	27.611	9056.0	408.5	Poor	No ghats	Poor/almost silted up
Sankar Kund, Gokul	77.721	27.433	2442.7	197.9	Poor	1 old ghat	Poor/ infested with algae
Sati Kund, Ladpur	77.557	27.730	21734.0	684.3	Moderate	No boundaries/ ghats	Poor/silted up
Sau Kund, Nari	77.522	27.659	5695.0	304.3	High	No ghats	Poor
Semari Kund, Sankh	77.494	27.395	11738.4	504.9	High	No ghats	Poor/polluted/used by cattle
Sesh Kund, Nari	77.535	27.673	12037.6	444.5	Poor	No ghats	Poor/deposition of silt
Sidha Kund, Jao	77.416	27.729	960.8	136.6	Poor	No ghats/boundaries	Poor/polluted/used by cattle

Name	Longitude (E)	Latitude (N)	Area (m^2)	Perimeter (m)	Water level	Structure/ ghats	Condition
Suraj Kund, Chhata	77.510	27.728	6679.0	326.9	Almost dry	4 old ghats	Poor/infested by aquatic weeds
Suraj Kund, Nibgaon	77.454	27.519	21925.3	578.4	Moderate	3 old ghats	Poor/polluted/used by cattle
Suraj Kund, Satwas	77.278	27.718	6039.0	320.8	Poor	3 old ghats	Poor/garbage dump
Swamibaba Kund, Ageryala	77.625	27.739	15011.0	511.9	Poor	1 old ghat	Poor/siltation high
Swamibaba Kund, Taroli	77.592	27.683	7423.0	355.6	Moderate	2 old ghats/stone	Poor/polluted due to silt
Swas Kund, Jao	77.391	27.731	1831.1	200.0	Poor	Earthen	Poor/water hyacinth
Tosh Kund, Tosh	77.565	27.526	11553	441.2	Poor	No ghats/boundaries	Poor
Triveni Kund, Senva	77.588	27.722	5874.6	306.5	Poor	1 old ghat	Poor/polluted water
Vihval Kund. Sanket	77.385	27.677	2631.2	296.7	Poor	Earthen	Poor/water hyacinth
Vimal Kund, Kaman	77.277	27.645	13839.0	462.5	Poor	No boundaries/ ghats	Poor/muddy water
Vishakha Kund, Kamai	77.426	27.629	4958.0	264.6	Poor	1 ghat	Poor/ muddy water
Yashoda Kund, Mahrana	77.320	27.719	16755.4	605.2	Low	No boundaries/ ghats	Poor/water poor state

N.B. Water level 'Poor' indicates maximum depth of water less than 1.0 m

Table 2 : Kunds under moderate category (Source: TBF, 2006)

Name	Longitude (E)	Latitude (N)	Area (m^2)	Perimeter (m)	Water level	Structure/ ghats	Condition
Bhola Kund, Bati	77.603	27.540	16887.0	475.9	Moderate	4 old ghats	Moderate Siltation
Gaun Kund, Jao	77.410	27.728	16074.0	529.3	Moderate	2 old ghats	Moderate Siltation
Gaya Kund, Kaman	77.267	27.641	38452.2	1058.2	Moderate	4 scattered ghats	Moderate Siltation
Godi Kund, Kharot	77.453	27.831	3798.4	246.5	Moderate	1 old ghat	Moderate Siltation
Gopal Kund, Bharna Khurd	77.495	27.581	6872.4	351.5	Moderate	Old pucca ghats	Moderate Siltation
Gopal Kund, Hathana	77.424	27.875	7730.6	371.8	High	1 old ghat	Moderate Siltation
Kishori Kund, Ajnokh	77.418	27.730	7123.5	537.9	Moderate	2 old ghats	Moderate Siltation
Krishna Kund, Nandgaon	77.389	27.712	1728.9	177.9	Moderate	Earthen	Moderate Siltation
Kua Ki Kund, Nandgaon	77.390	27.714	1690.5	184.9	Moderate	Earthen	Moderate Siltation
Matkana Kund, Ajhai	77.603	27.650	5482.2	296.8	Moderate	4 old ghats	Moderate Siltation
Prahlad Kund, Mathura	77.680	27.502	1845.7	172.8	Moderate	3 old ghats	Moderate Siltation
Renuka Kund, Jakhangaon	77.539	27.512	9083.0	470.3	High	No ghats	Moderate Siltation
Shyam Kund, Perkham	77.625	27.630	18117.0	496.8	High	No boundaries/ ghats	Moderate Siltation

Name	Longitude (E)	Latitude (N)	Area (m^2)	Perimeter (m)	Water level	Structure/ ghats	Condition
Shyam Kund, Senva	77.592	27.721	6063.0	352.2	High	7 ghats/ boundaries	Moderate Siltation
Varuni Kund, Viharvan	77.558	27.545	5814.0	299.7	Moderate	No ghats	Moderate Siltation
Vishakund, Nari	77.522	27.661	13165.0	531.1	High	No ghats	Moderate Siltation
Vishma Kund, Raal	77.562	27.555	8260.0	376.1	High	4 old ghats	Moderate Siltation
Prahlad Kund, Mathura	77.680	27.502	1845.7	172.8	Moderate	3 old ghats	Moderate Siltation
Yashoda Kund, Nandgaon	77.386	27.702	11432.0	481.1	Moderate	Earthen	Moderate Siltation

Table 3 Kunds under good category (Source: TBF, 2006)

Name	Longitude (E)	Latitude (N)	Area (m^2)	Perimeter (m)	Water level	Structure/ ghats	Condition
Kusum Sarovar, Govardhan	77.479	27.512	8338.0	440.6	High	4 good ghats	Good/ maintained
Narad Kund, Govardhan	77.482	27.508	6498.0	311.1	Moderate	None	Good
Patitpavan Kund, Palso	77.415	27.573	9308.4	431.5	Moderate	8 pucca ghats	Good
Pawan Sarovar, Nandgaon	77.384	27.715	11341.9	416.6	High	4 good ghats	Good/ maintained
Prem Sarover, Gazipur	77.380	27.665	1738.5	170.7	High	4 good ghats	Good/ maintained
Potara Kund, Mathura	77.505	27.713	5477.1	296.3	High	Pucca ghats all sides	Good
Radha Kund, Govardhan	77.487	27.524	10648.0	418.0	High	4 lined ghats	Good
Sudarshan Kund, Kunjera	77.455	27.548	10508.2	411.9	Good	2 pucca ghats	Good
Suraj Kund, Dabhala	77.360	27.629	2873.4	210.3	Poor	Pucca ghats all sides	Good/ in need of water

Based on the above survey, the status of most of the kunds can be summarized as:

1. Depth of water: shallow to moderate
2. Siltation: moderate to high
3. Water quality: high algal bloom, water lilies, sewage dump
4. Structures: old ghats, broken

REASONS FOR DETERIORATION OF THE KUNDS

1. Rapid urbanization: Due to rapid urbanization, the areas surrounding many of the kunds have been encroached upon and habitations have been built up. As a result, the catchment area contributing to the kunds are existing no more. Sewage systems or domestic wastes in some places find their opening into some of the kunds, for which some of the kunds have turned into garbage tanks. Plate 1 shows Brahma Kund in Vrindavan engulfed by the habitations.
2. Non-point loading: Agricultural and urban activities are the major non-point sources of silt and nutrients into the kunds. Agriculture is the primary source of non-point loading through erosion of nutrient-rich soil and from livestock activities (Novotny, 1999). Demands to increase agricultural production with fertilizer applications have led to soil nutrient surpluses, particularly phosphorus (P). Surplus soil P is the basis of non-point runoff, with 3-20% of that applied reaching surface waters (Caraco, 1995). Runoff from crop fields, especially fields treated with manure, is high in biologically available P and may easily reach surface water bodies. Urban runoff, though somewhat less significant than agricultural runoff, is also a large source of nutrients to fresh water. As urban areas expand, undeveloped land is drained, deforested or tilled and stored soil nutrients are released. Both urban and agricultural runoff have higher peak discharge and flow volumes than undisturbed areas, although soil type, percent impervious area, climate and physiography influence these variables. Urban runoff also adds bacteria, silt, toxins and BOD-demanding materials (USEPA, 1993).

Plate 1 Brahma Kund, Vrindavan (Courtesy: The Braj Foundation, U.P., India)

Plate 2 Govind Kund, Vrindavan(Courtesy: The Braj Foundation, U.P., India)

3. Eutrophication: The most obvious, persistent and pervasive global water quality problem at this time is Eutrophication. Water bodies have deteriorated through excessive loading of plant nutrients, organic matter and silt, that cause increased primary producer biomass, reduced water quality, good growing condition for nuisance species and decreased water volumes. Eutrophic water bodies lose much of their beauty and their usefulness and safety for domestic water uses. Traditionally, eutrophication only referred to nutrient loading, but, silt and organic matter have additional effects on the water body besides their nutrient content and therefore, cannot be excluded (Cooke et al, 2005). Organic matter, whether added to the water body from external or internal sources, lead to increased nutrient availability via direct mineralization or through release from sediments when respiration is stimulated by this organic matter and DO is depleted. Net internal P loading appears to increase exponentially with increasing dissolved carbon content of the water body (Ryding, 1985). Finally, organic matter added to a water body contains energy that is incorporated into plants and animal biomass in both dissolved and particulate forms, leading to increased living biomass. Silt

may be rich in organic matter and nutrients which become available to algae or macrophytes immediately or some later stage. This fosters further spread of macrophytes or algae, which ultimately promote further loss of DO and release of organic molecules and nutrients as they decay (Carpenter et al., 1998). Plate 3 and 4 shows silt-laden water and macrophytes infestation in the kunds, respectively.

Plate 3 Dharam Kund, Jao
(Courtesy: The Braj Foundation, U.P., India)

Plate 4 Gauri Kund, Kaman
(Courtesy: The Braj Foundation, U.P., India)

PROBABLE RESTORATION TECHNIQUES:

Cairns et al. (1992) defined restoration as "return of an eco-system to a close approximation of its condition prior to disturbance". Though actual restoration is not possible, this concept emphasizes return of the degraded systems to attainable approximation of pre-disturbance conditions, and establishment of protections against future disturbances.

1. Storm water interceptors: The most obvious step towards improving water quality is to limit or arrest excessive external loading. Non-point loads into the kunds can be reduced by intercepting storm water runoff through silt traps or grassy swales (biofilters). A silt trap is a containment area where silt-laden runoff in temporarily detained under quiet conditions allowing silt to settle before the runoff is discharged through a gravel outlet. Silt traps can be formed by excavating or constructing an earthen embankment across the catchment areas of the kunds. Its purpose is to collect and store sediment from sites cleared or graded during construction or agricultural operations. It helps in removing coarse sediments from runoff. The trap is a temporary measure with a design life of six month to one year and is to be maintained until the site is protected against erosion by vegetation. Silt traps should be used only for small drainage areas, less than 5 acres. If the contributing catchment area is large, it can be subdivided into small drainage basins. Another good technique is grassy swales which are gently sloped conveyance channels with dense vegetation. These are designed to provide at least 10 minutes of residence time for filtering a substantial portion of P, Cu, Zn, Pb, etc. in the runoff water. Soil infiltration capacity should be more than 0.5 in/h. This practice is not practical in areas with steep topography or poorly drained soils (USEPA, 1995).
2. Dilution/Flushing/Withdrawal: These techniques are useful for manipulating internal chemical, biological or physical conditions to restore the water body. Dilution involves the addition of low-nutrient water to reduce nutrient concentration in the water body and can be effective where external or internal sources are not controlled. Flushing simply removes algal biomass, although that may require huge volume of water. These practices have limited applications due to the lack of availability of large volume of low-nutrient water. Nutrient enriched waters may be removed through siphoning, pumping

or selective discharge sites instead of applying low-nutrient water. This has shown to be effective at reducing P concentrations and improving oxygen content in water (Cooke et al, 2005).

3. P inactivation: Internal release of P is a significant problem that may hinder the improvement of water quality. Sediment P release can be controlled by adding aluminum salts to the water column resulting in aluminum hydroxide that settles to the sediment surface forming a barrier to further release. This is a powerful and popular technique.
4. Sediment removal: This technique can be multipurpose, resulting in control of both algae and macrophytes. It is an effective procedure and is frequently used for deepening shallow water bodies for curtailing internal nutrient loading by eliminating the enriched sediment layer and macrophytes control. It has a significant long-term advantage over nutrient inactivation due to the fact that the source is removed rather than bound in place as in case of P inactivation. The limitations of this technique are the relatively high cost of dredging and the requirement of adequate dredged material disposal sites.

CONCLUSIONS

The present study provides an account of the hydrological condition of the kunds in Braj, which shows that most of the kunds are silted up, dry and of poor quality water. There is an urgent need for taking necessary measures to restore the kunds for the welfare of the mankind at large. Some technical suggestions have been made to revive the kunds so that they can fulfill fresh water needs in the area in future. Diagnosis of the problems and their present condition or severity in a kund should be the primary task. After evaluating this, appropriate cost-effective treatment(s) should be selected to achieve a particular objective in the kund like control of algae growth, minimization of external or internal loading, sediment removal, etc.

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