

Pollution due to backwater Tourism and possibilities for use of Green Energy Technologies

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Abstract— Backwaters in Kerala state of India are water bodies nourished by rivers but there is little or no water current and in most cases connected to the sea. Vembanadu lake, the largest backwater in the state is also the largest wetland system in South India. The major attraction of the area is backwater tourism and is emerging as the main income source of the region since the introduction of houseboats. Vembanadu lake is included in the Ramsar sites and there is a great concern on the environmental degradation due to the backwater tourism. Hence a study was taken up to assess the ecological threats to the backwaters due to pollution. It was found that pollution from untreated sewage waste, seepage of oil from engine driven boats, discharge of non-biodegradable wastes were serious issues. Possibilities to use green energy technologies such as bioenergy and solar energy were evident in the study.

Keywords— Backwater tourism, Environmental pollution, Renewable energy, Bioenergy, Solar energy.

I. INTRODUCTION

Vembanad lake is spread over the districts of Alappuzha, Kottayam and Pathanamthitta of Kerala state and is famous for backwater tourism. This wetland system lie in the humid tropical region between 09°00' -10°40'N and 76°00'-77°30'E. It is unique in terms of physiography, geology, climate, hydrology, land use and flora and fauna [1]. The lake is identified as a Ramsar wetland and supporting a bird population of more than 20,000 during winter [2]. The lake is also home to many rare and endangered species of fishes and birds.

In the past few decades Vembanadu lake has emerged as a major tourist attraction in Kerala. In former days, traditional boats used for transporting goods ('kettuvallam' in Malayalam) were mainly used for transportation of agricultural products to the markets and ports. With the change in the mode of goods transportation they were converted to house boats which are now the icon of back water tourism in Kerala. The traditional looking house boats are attractive to tourists and now tourism is a major economic activity in the area.

But, the population of houseboats has increased significantly in the recent years creating a serious concern on their impact on the wet land ecosystem. Even though there are legal restrictions and rules imposed by the government to mitigate the environmental impacts of

house boat tourism, there are many instances of negligence on the part of the operators. The waste from houseboats consisted of solid wastes including food wastes and liquid wastes like sewage [3]. Large quantities of diesel fuel are also being used for propulsion of boats resulting in pollution due to diesel and oil spilled from engines. Most house boats are air conditioned and they use diesel generators throughout the day. In an effort to mitigate global warming the concept of "low-carbon tourism" is emerging so as to provide a good tourism experience; but taking efforts to lessen carbon emission and pollution [4]. A study to identify the challenges to eco-friendly tourism has suggested changes in the "water-energy-food nexus" in vulnerable tourist locations [5].

There were efforts to study the possibilities of in-situ bioenergy production in wetlands for their sustainable management [6]. Biodiesel is biodegradable and its spill is not fatal for aquatic life as petro diesel spills. This renewable fuel can be used either in pure form or in blends with petro-diesel in unmodified engines. Countries like Philippines have been trying to introduce coconut oil biodiesel in the transport sector [7]. Even though coconut is an important crop in Kerala, little attention is seen paid on the production and use of coconut oil biodiesel. A number of Pacific island countries have plans for complete switch over to renewable energy with a major

focus on solar PV coupled with indigenous bioenergy production [8]. Utilisation of PV technology for powering the gadgets used in houseboats also is a possibility in the present context. In addition, the organic solid wastes including food wastes and sewage can be treated in anaerobic systems to produce biogas.

Hence a study was taken-up to understand the major pollution problems associated with back water tourism in Vembanad Lake and to propose suitable renewable energy techniques for reducing carbon emission and pollution.

II. MATERIALS AND METHODS

2.1 Data collection

The methodology adopted for the present study was a mix of primary data collection through surveys as well as analysis of secondary data collected from various stakeholders. The survey was conducted during the months of February to April 2016. The pollution hazard in the area becomes severe in this period of the year due to the closing of the regulator (*Thaneermukkam bund*) which controls the outflow of lake water to Arabian sea, resulting in the stagnation of wastes in the backwaters. Information was gathered by interviews with key stakeholders, focus group discussions and interactions with a number of selected respondents. The office bearers of All Kerala House Boat Owners Association were also consulted (Table 1). Data from the Kerala State Pollution Control Board and documents from the Department of Port, Government of Kerala, were reviewed. The analysis was based on the surveys at two locations viz. Alappuzha and Kainakary. The present strategy and facilities for waste management available for the houseboats were also studied with a view to assess the usefulness.

2.2 Study of sewage treatment system

A survey was also done to assess the usefulness of the present waste management system. The technology used for the present system with respect to the requirement and technology options was also examined.

2.3 Assessment of renewable energy options

Based on the above studies and in consideration of the geo-physical and climatic factors, suitable renewable energy options were suggested.

Table 1. Details of informants

Sl. No	Category of informants	Total number	Percent of informants
1	Local inhabitants	50	38
2	House boat workers	35	27
3	Tourists	45	35
	Total	130	100

To quantify the possible biogas production potential of mixed organic wastes generated in houseboats, a random survey was undertaken in the Kuttanad area. Standard design procedures [10] were adopted for arriving at the design dimensions.

Solar energy availability was assessed by estimating the monthly average daily global radiation on a horizontal surface using the Page's equation [11].

$$H_o = \frac{24}{\pi} I_{sc} \left\{ 1 + 0.033 \cos \frac{360}{365} n \right\} \{ \omega_s \sin \phi \sin \delta + \cos \phi \cos \delta \sin \omega_s \} \quad (1)$$

'*H_o*' is the monthly average of the daily extra-terrestrial radiation on unit area of a horizontal surface at a specific locality of latitude ϕ (9.6° N)

'*I_{sc}*' is the solar constant (1367 W/m²)

'*n*' is the day of the year (1st January taken as 1)

' ω_s ' is the sunrise hour angle.

' δ ' is the solar declination estimated using the Cooper equation,

$$\delta = 23.45 \sin \{ 360(284 + n)/365 \} \quad (2)$$

The monthly average daily global radiation actually incident on a horizontal surface is given by [11]:

$$H_g = H_o \left[a + b \frac{h}{H} \right] \quad (3)$$

'*h*' is the actual daily sun shine hours (ranged from 8.5 hours to 10 hours depending on the climatic condition) and '*H*' is the maximum possible sunshine hours on a particular day in the specific locality. '*a*' and '*b*' are constants. For this study the constants for Thiruvananthapuram were taken into consideration i.e. *a*= 0.37 and *b*= 0.39.

III. RESULTS AND DISCUSSION

The general information collected from different classes of local inhabitants as well as tourists gave a picture of



Fig.1. Perspectives of different classes of informants on pollution due to house boats

the environmental problems as well as their perceptions on the severity of problems.

3.1 General perception of respondents

The perspectives of the different classes of respondents when they were asked to record their opinion on the environmental hazard as ‘very much’, ‘slightly’ and ‘not significant’ were as shown in Fig.1. Out of the 130 respondents surveyed local inhabitants were the maximum (50) and majority of them were skeptical about the house boat tourism.

When 66 % of the local people and 51 % of tourists opined that the houseboat tourism ‘very much’ pollutes the environment, only 7 % of houseboat workers admitted that. More than 48% of the total respondents felt that houseboat tourism affected the environment ‘very much’. But, 32% of the respondents were of the perception that the environmental problem due to this venture was not significant. About 20 % of them opined that there was slight effect on the environment. In general, people who got direct financial benefit from the venture tried to see the issue as insignificant whereas most local inhabitants felt the pollution issue, even though they seemed to benefit from the venture indirectly. From Fig. 1 it is clear that local inhabitants as well as tourists were concerned about the environmental problems even though the house boat workers seemed to neglect them. The personal biases of the respondents are evident from this.

3.2 Assessment of sewage treatment plant

Another query addressed in the present study was the usefulness of the sewage treatment plant installed by the District Tourism Promotion Council in collaboration with the houseboat owners’ association. It was intended to prevent the discharge of sewage from house boats to the lakes and was supposed to have a treatment capacity of 180,000 litres of sewage per day. A layout of the system is shown in Fig.2. The sewage management process involved collection of raw sewage from house boats to an

Table 2. Perception of respondents on the extend of utilization of the sewage treatment plant

Respondents →	Local people		House boat crew		Officials	
	No.	%	No.	%	No.	%
Perception on usage ↓						
Well used	16	23.53	25	62.50	4	11.76
Low usage	12	17.65	15	37.50	10	29.41
Rarely	40	58.82	0	0.00	20	58.82
Total	68	100.00	40	100.00	34	100.00

equalization tank. Natural aeration by recirculation by the feed pump was expected to homogenise the effluent from the equalization tank which was fed to a reactor. The reactor working on electricity was based on the principle of electro-coagulation. The treated sewage coming out from the reactor was passed through a clarifier tank where the solids settle down. The clarified water was collected in a feed tank from which water was fed to a pressure sand filter and activated carbon filter. The outflow of the carbon filter was further treated by passing through an electro chemical oxidation unit for microbiological disinfection and the treated water was finally discharged to a soak pit.

From the survey, it could be understood that different class of people had different perceptions on the utilization of the treatment plant as shown in Table 2. More than 58 % of the local people felt that the treatment plant was not effectively used by the houseboat operators. They complained that the sewage from the houseboats were most often not transferred to the treatment plant and were dumped into the backwaters. The toilet sewage and other liquid wastes from the households on the bank of lakes also often found their way into the lakes. More than half

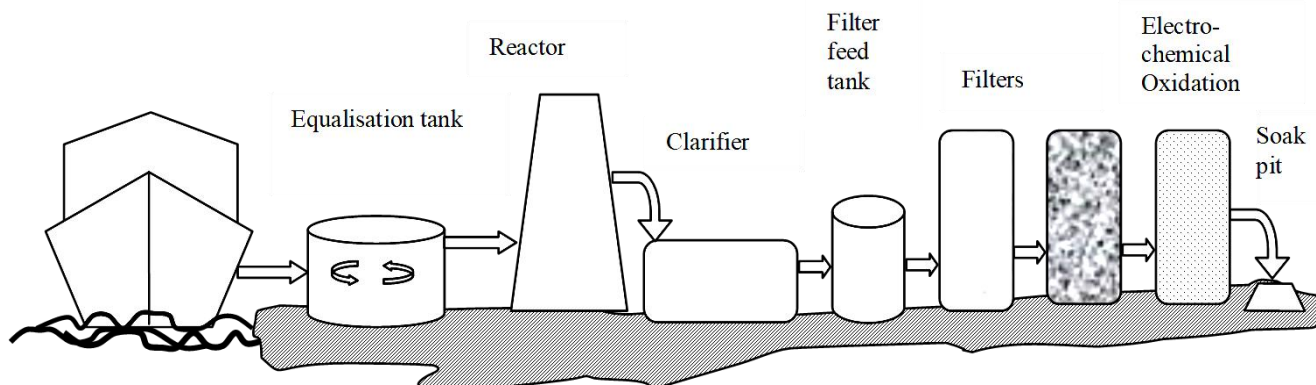


Fig.2. Layout of the sewage treatment plant

Table 3. Pattern and quantity of waste generation in house boats of Kuttanad region

Sl. No.	Particulars	Quantity
1	No. of house boats in Kuttanad region of the lake	838
2	Average number of house boats in daily service	465
3	Average number of persons per boat	10
4	Total amount of biodegradable solid wastes	1488 kg
5	Total amount of recyclable plastic waste	697 kg
6	Wastes to be incinerated	93 kg
7	Waste water	232.5 m ³

of the respondents endorsed that the management of wastes and sewage is not at all done in a proper way. But majority of the houseboat crew (60%) responded against this and claimed that they do not dump sewage into the lakes. However a large percentage of the local people had the opinion that water and soil characteristics had been badly affected because of the backwater tourism. As per their opinion oil spill from engines also cause deterioration of the ecosystem. These observations call for urgent measures to address the issue of pollution so as to protect the ecosystem of the *Vembanad* backwaters.

The pattern and extend of waste generation in house boats are shown in Table 3. It was fairly evident that if a proper waste management strategy is implemented the pollution issue could have been addressed in a much better way than being done presently. It can be seen that the major portion of the wastes generated is waste water from bathrooms and kitchens of house boats which is difficult to be carried to the treatment plant and treated as the quantity is large. The better way to lessen the pollution will be the usage of less harmful detergents and chemicals. The tourists need to be educated on these aspects and they should be persuaded to follow an eco-friendly protocol for personal hygiene. If eco-friendly detergents with medicinal qualities are promoted they can replace soaps and other detergents to a great extent. If this is possible, the major portion of waste waters can be disposed in-situ without causing substantial harm to the aquatic life.

3.3 Possibilities for eco-friendly waste management and use of renewable energy

The non-biodegradable plastic wastes and biodegradable solid wastes should be segregated at the

source itself and transferred to collection centres located at convenient places. The biodegradable wastes can be used for biogas production. The waste generation pattern is shown in Table 3. About 1.5 metric tonnes of biodegradable waste is available for anaerobic digestion for energy production. Assuming an average biogas productivity of 60 litres per kg of organic wastes, total biogas that can be produced amounts to almost 90 m³. The Total Solids of the organic wastes fed to the biogas plant is likely to get reduced to 40 percent and hence the quantity for further treatment gets reduced. The output from the biogas plant may be treated for removal of pathogens and subsequently converted to organic manure. Only a small quantity of the waste needs to be incinerated for which the biogas can be utilized. The operation of treatment plant as well as other energy needs of the waste management system can also be met from the anaerobic system as fuel with a total heating value of 1800 MJ is available considering the heating value of biogas as 20 MJ/m³. Decentralisation of the waste management system is also possible, as small systems which can manage about 500 kg of wastes can be installed. Thus the size of the plants can be reduced as there are limitations due to high water table. As the wastes are having a high water content addition of further water for digestion may be limited so as to have about 10 % TS for the input material. Special and unconventional designs of anaerobic digesters may be required in Kuttanad area as the water table is high in most locations. Possibility of floating type digesters which can be anchored to the shores also can be considered. The proposed design aspects and dimensions of the biogas system is given in Table 4.

The estimated availability of solar energy during the months except June and July (off season) are shown in Fig. 3. The mean daily solar radiation incident on unit area of a horizontal surface during the 10 months period amounts to 24,358 kJ. Even though the cloud cover is less during the months of January and December, the solar energy availability is less due to the reduction in

Table 4. Design aspects of biogas system

Particulars	Capacity/ Quantity
Daily waste feed	500 kg
Total daily input volume	750 litres
Retention time	50 days
Capacity of digester	37.5 m ³
Daily gas production	30 m ³
Gas holder capacity	15 m ³ (50% storage)

maximum possible sunshine hours, which is dependent on the position of the Sun relative to Northern hemisphere. The maximum possible sunshine hours is decided by the latitude as well as solar declination. The declination is negative and maximum during this period. The maximum possible hours of sun shine are during the month of May the period being near to the summer solstice. Even though summer solstice occurs in June, due to the monsoon clouds there will be very less hours of bright sun shine, and the monsoon season of June and July has not been considered for the analysis. The maximum solar energy availability is in the month of March due to the reduction due to cloud cover in the month of May. It is noteworthy that sufficient solar energy is available during the tourist peak seasons.

At present, either diesel generators or electricity from the grid is used for powering the air conditioners and lights in the house boats. Solar charging stations on the shores could very well be used at least for lighting needs. Many houseboat owners are not favouring installation of roof top PV panels on boats due to the fact that the panels do not suit the aesthetic requirements of traditional looking house boats. However, floating PV installations in the lake is a possibility. New architecturally attractive design of solar panels to match the traditional house boats also is an alternative. As house boats are slow moving vessels, use of electric drives for propulsion of the boats needs to be seriously considered. There has been studies to evolve design procedure for solar PV powered boats [13]. Possibility of PV power stations to energise batteries is a possibility as new technologies are emerging in electrical energy storage. There has also been efforts to explore the potential of renewable energy use in isolated islands such as the Corales del Rosario Archipelago a national park of ecological importance in the Colombian Caribe [14].

Apart from solar PV, there is also a possibility to use solar thermal energy also. In general no solar water heaters were seen installed on the houseboats. Some area of the roof can be used for installation of a solar water heater without affecting the aesthetics of the boats. As food is being cooked inside the boat with LPG stoves, hot water availability for cooking can tremendously reduce the fuel requirements.

Another alternate green energy option is the use of coconut oil biodiesel for propulsion of boats. The current price of coconut oil is much higher than diesel fuel and hence the economic aspects of coconut oil biodiesel are not promising. But, the reduction in emission combined with the possibility of biodegradability in the instance of oil spills are factors favouring biodiesel usage for

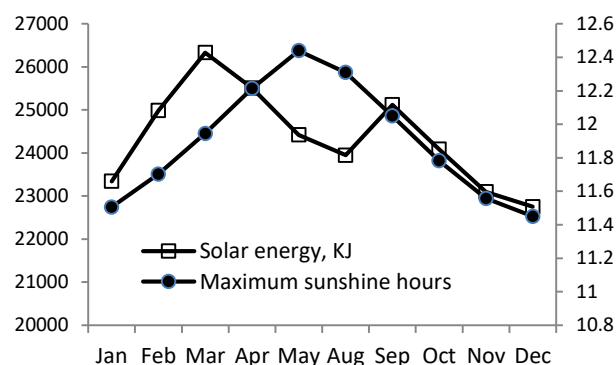


Fig.3. Monthly average daily solar radiation, kJ/m^2

propelling houseboats. Prior studies have already proven [12] the advantages of coconut oil biodiesel in combating pollution due to diesel fuel.

IV. CONCLUSION

An overview of the pollution hazard due to tourism in the *Vembanad* backwater revealed the following salient aspects:

- i. The wetland ecosystem of the *Vembanad* lake is adversely affected by the tourism activities, especially houseboats.
- ii. The present waste management system is inadequate to keep the serenity of the area and the local people are badly affected by the pollution hazard.
- iii. Proper waste management strategies coupled with utilisation of renewable energy is recommended for reduction of carbon emission and environmental protection.
- iv. Anaerobic digestion of organic biodegradable wastes with simultaneous production of energy is a possibility. Decentralisation of waste management facilities and promotion of eco-friendly practices in tourism sector need to be promoted.
- v. Utilisation of solar photo-voltaic power generation has good scope as revealed by the analysis of solar radiation availability.
- vi. Solar thermal energy utilization by way of solar water heaters is a readily available technology and can be utilised in the houseboats.
- vii. Use of coconut oil biodiesel to replace diesel fuel used in house boats is also one among the possibilities of green energy technology even though the economic feasibility is not promising.
- viii. Integrated and decentralised waste management approach along with renewable energy usage is required to impart eco-friendly tourism in *Vembanad* lake.

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