International Research Journal of Biological Sciences ISSN 2278-3202
Vol. **4(3),** 1-5, March **(2015)** *Int. Res. J. Biological Sci.*

Heat Budget of three Limnological important sites of Narmada river, India

Virendra Kumar Soni*[1], Mohammad Dilshad Hussain[2], Sharad Shrivastava[2], Khwaja Salahuddin[3] Manish D. Visavadia[1] and Chirah M. Gosai [1]
[1*]Department of Zoology, Bahauddin Science College, Junagadh-362001, Gujarat, INDIA
[2]School of studies in Zoology and Biotechnology, Vikram University, Ujjain, MP, INDIA
[3]Department of Botany, Bahauddin Science College, Junagadh-362001, Gujarat, INDIA

Available online at: www.isca.in, www.isca.me
Received 20th May 2013, revised 9th December 2014, accepted 10th January 2015

Abstract

Heat budget can be defined as the amount of heat energy required annually to raise the temperature of a water body from its winter minimum to its summer maximum. To evaluate the extent to which global climate change is affecting the thermal evolution of a lake, river it is necessary to know the annual heat balance of the water body. The productivity of an aquatic body and the metabolism, physiology, behavior of organism's inhabitat are directly or indirectly related to the temperature of the aquatic environment. The present study was aimed to ascertain the evaluation of heat storage capacity in the form of heat budget at three limnological important sites of the Narmada river. It was conducted on monthly basis for the year 2010. The heat contents were found to be ranged between 16110 – 57550 cal/cm^2. Its highest contents were reported at koteshwar dam site while least at Maheshwar dam site. The results showed inefficient or uneconomic heat budget wherein the efficiency of conversion of heat energy towards the biomass and biogenic phenomena is minimum, it is mainly due to excessive evaporation and strong wind currents and its interruption by several submerged rocks reduce the efficiency of utilization of heat energy for biogenic phenomena. It indicated the healthy status of the river.

Keywords: Heat budget, limnology, productivity.

Introduction

Annual heat balance is the amount of heat contained in the lake annually, expressed as joules or calories per unit area. The transport processes and spatial distribution of oxygen and nutrients in the water body are controlled by temperature stratification and heat storage therefore a solid understanding of the river's thermal structure and of the dynamics controlling that structure is vital to ecological management decision. One of the most important and interesting characteristics of an aquatic system is its thermal structure. The heat content of a body of water is of vital importance in limnology. Heat budget provides quantification of the energetic of heating and cooling determining the resistance of water body to mixing. Radiation from sun and sky is by far the most important of the heating processes. On the other hand quantitative information on heat generated in chemical changes and heat resulting from friction in water movements is obscure or wanting, but the supposition is that these sources of heat are minor and, for limnological purposes, may be disregarded. Huang and Izumiya[1] described the importance of water temperature regimes for the health of aquatic life, and insight into the impact of upstream control on downstream water temperature regimes. Unfortunately, heat budgets have received far too little attention in the past, and so few lakes and rivers have been studied with regard to this matter that dependable conclusions of a general nature are still lacking.

Material and Methods

Narmada is the fifth largest river of India. It is commonly known as the Life line of Madhya Pradesh, it originates from eastern Madhya Pradesh at Amarkantak situated at 20^{0}40', 80^{0}45' E, and flows towards west and joins Arabian Sea at Broach situated at 20^{0}43', 72^{0}57' E. Present research was conducted on the three study sites of limnological importance viz. Omkareshwar dam (figure-2), Maheshwar dam (figure-3), and Koteshwar dam site (figure-4). Water temperature was taken on monthly basis from different strata and mean values were used to calculate heat budget. Temperature was taken by Orion Thermo probe (50 meter). A constant surface area 100 m^2 is used for its calculation and the thickness or depth in cm. (depth cm. x area cm ^{2} = cm ^{3}) can then be multiplied directly by temperature in ^{o}C to obtain caloric content. as per the method given by Wetzel and Likens [2] by applying following formula.

$$\Theta_w = \sum_{z_o}^{z_m} t_z A_z h_z$$

Where: θ_w = heat content of the water in calories. Zo = surface of the water body. Zm = maximum depth of water body. t z = average temperature in ^{0} C of a unit layer of water of thickness hz in cm., with the midpoint at depth z. Az = the area at depth z in cm^2. The heat content is usually expressed on a unit area basis $\theta w / A_o$ in cal/cm^2

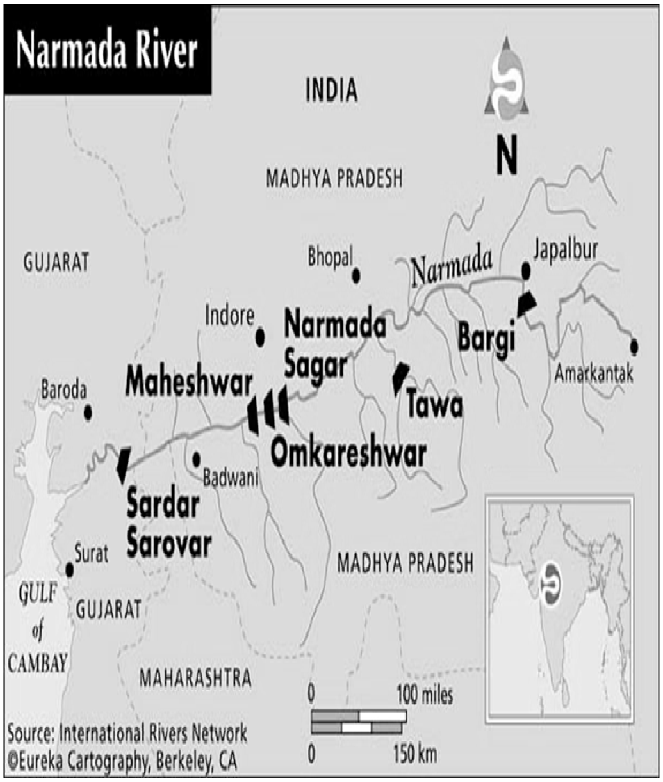

Figure-1
Map of Narmada river, India

Figure-3
Maheshwar dam site

Figure-2
Omkareshwar dam site

Figure-4
Mandleshwar dam site

Results and Discussion

In the present study heat storage capacity was found to be ranged between 27440 – 47250 cal/cm^2 at Omkareshwar dam site (figure-5), 16110 – 26550 cal/cm^2 at Maheshwar dam site (figure-6) and 28260 - 57600 cal/cm^2 at Koteshwar dam site (figure-7). A maximum of heat contents 57600 cal /cm^2 was reported at Koteshwar dam site in July 2010. A minimum of heat contents 16110 cal/cm^2 was reported at Maheshwar dam site in January 2010. The seasonal values of heat storage capacity indicated its maximum value in monsoon season followed by summer and winter subsequently (table-1).

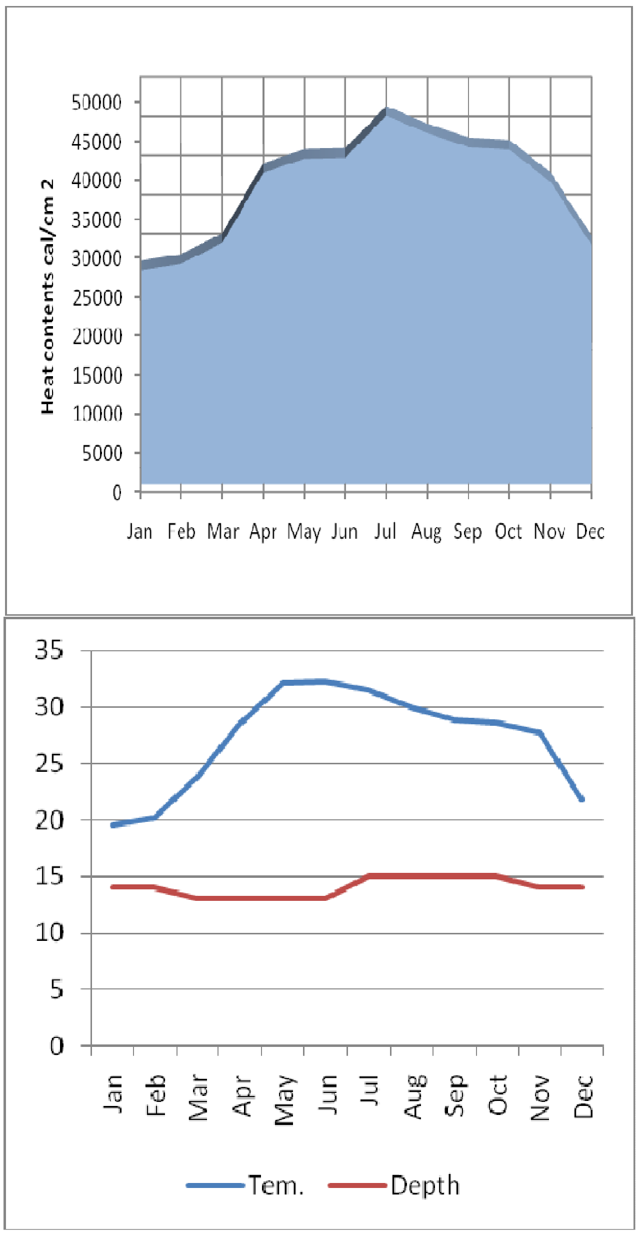

Figure-5
Heat contents (cal/cm ^{2}), temperature (^{o}C) and deapth (m.) at Omkareshwar study site

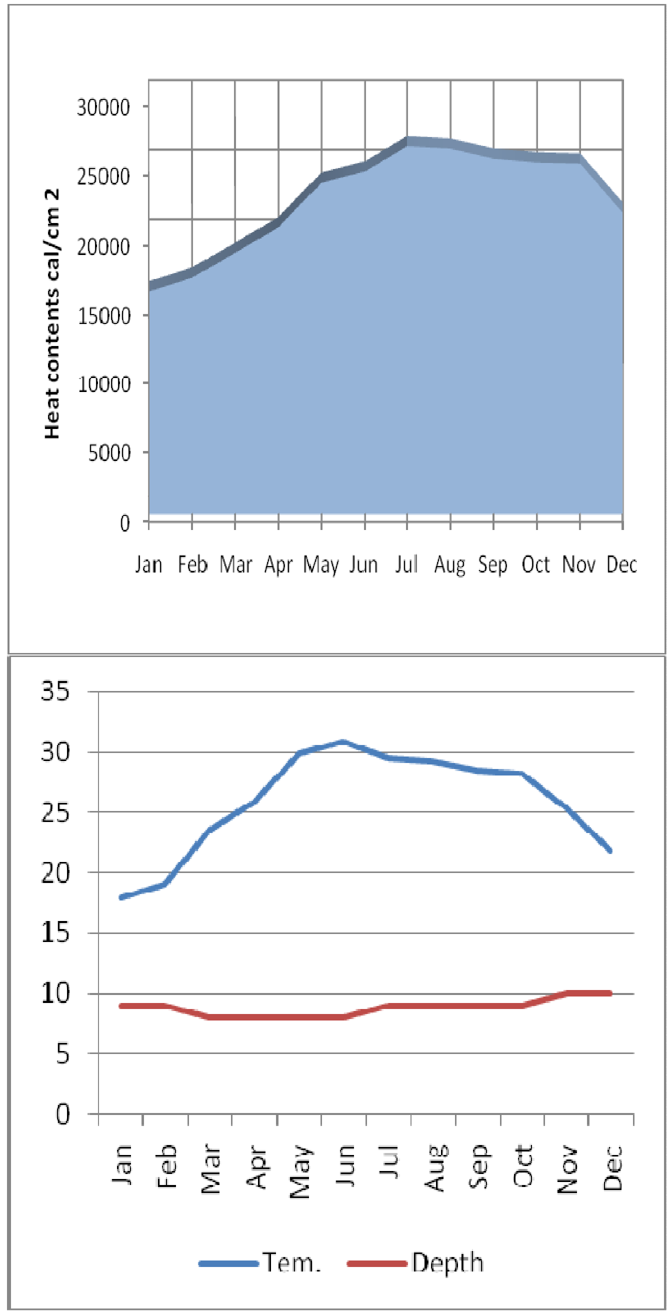

Figure-6
Heat contents (cal/cm ^{2}), temperature (^{o}C) and deapth (m.) at Maheshwar study site

The heat budget of impoundments may differ greatly from that of natural lakes depending on the design of the dam. If water is released from the bottom as with the case of dams designed for hydroelectric power generation, cold nutrients rich but oxygen – poor water is exported downstream while warm water is retained in the lake. The impoundments than become a heat trap and nutrient exporter in contrast to natural lakes, which discharge from the surface and therefore function as nutrient traps and heat exporters, Munshi and Munshi[3] .

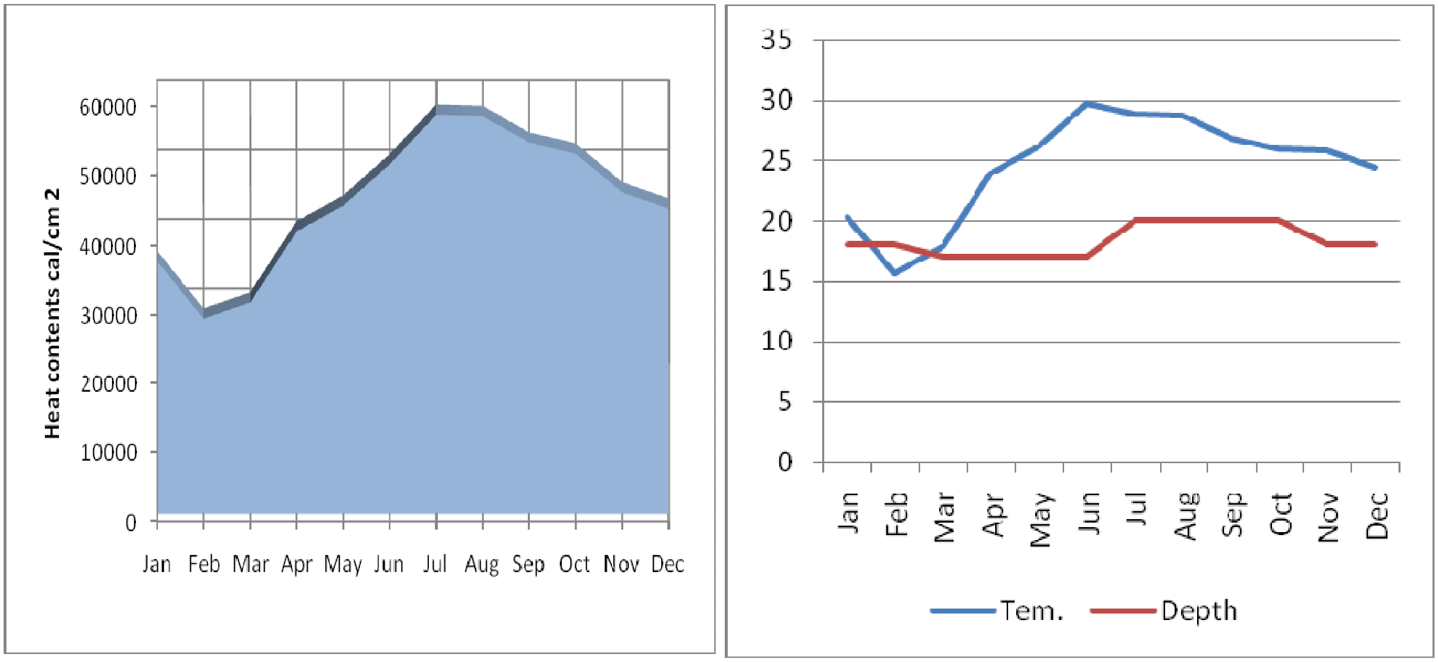

Figure-7
Heat contents (cal/cm^2), temperature (^{o}C) and deapth (m.) at Koteshwar study site

Table-1
Monthly values of mean temperature and heat contents at different study sites of the Narmada river for the year 2010

Months	Omkareshwar dam site			Maheshwar dam site			Koteshwar dam site		
	Tem. ^{o}C	Depth m.	Heat con. cal/cm ^{2}	Tem. ^{o}C	Depth m.	Heat cont. cal/cm ^{2}	Tem. ^{o}C	Depth m.	Heat cont. cal/cm ^{2}
January	19.6	14	27440	17.9	9	16110	20.3	18	36540
February	20.2	14	28280	19.0	9	17100	15.7	18	28260
March	23.8	13	30940	23.6	8	18880	18.0	17	30600
April	28.4	13	39920	25.9	8	20720	24.0	17	40800
May	32.1	13	41730	29.9	8	23920	26.2	17	44540
June	32.2	13	41860	30.9	8	24720	29.7	17	50490
July	31.5	15	47250	29.5	9	26550	28.8	20	57600
August	30.0	15	45000	29.3	9	26370	28.7	20	57400
September	28.8	15	43200	28.5	9	25650	26.8	20	53600
October	28.6	15	42900	28.2	9	25380	26.0	20	52000
November	27.7	14	38780	25.3	10	25300	25.8	18	46440
December	21.9	14	30660	21.8	10	21800	24.5	18	44100

Study indicated the best heat storage capacity takes place in the month of July, August and September representing the rainy season and not in the summer and winter months when excessive heat courses in the environment. Several authors reported affect of discharge of cool and hot water into various water bodies. Stewarr[4] showed the affect of power plant thermal discharge input to Lake Monoma (Wisconsin).

Crips[5] discussed the depth of water appears to be a curial factor in the thermal budget of a water body. The inflow and outflow of water into and out of the reservoir has profound influences on thermal regime of reservoir as stressed by Vivier[6]. Gorham[7] reported magnitude of heat budget is influenced by morphometric parameters such as mean depth, area and volume. Hutchinson[8] also reported magnitude of heat budget is influenced by several factors including latitude, altitude and thermal behavior. Sreenivasan[9] reported annual heat budget of 78,721 g cal in Amaravathy reservoir for 1963 while studying the limnology of tropical impoundments. The low values 2,300 cal/cm^2 of annual heat budget were reported by sreenivasan[10] from Aliyar reservoir. In temperate lakes that are sufficiently deep to maintain hypolimnetic temperature near 4 ^{0}C year round – Birgean heat budgets usually vary between 30000 – 40000 cal cm^{-2} year^{-2}, [11]. Soni[12] reported heat contents were affected by temperature and depth in their study on the river Narmada. The present research pointed out that the chief thermal inputs of heat gains in the aquatic ecosystem are by incident sunlight at the surface where maximum heat absorption takes place.

The heat losses of the Narmada River may be due to the evaporation of water, sediments and the utilization of heat in the metabolic activities and strong wind flow. A maximum value of heat budget 57600 cal/cm^2 at koteshwar dam site in monsoon season which may be attributed due to its maximum depth (20 mts.), less evaporation of water and low metabolic activities at this site of the Narmada river. A minimum value 16110 cal/cm^2 was observed at Maheshwar dam site in winter season, it may be due to least depth (10 mts.) presence of submerged rocks, utilization of high amount of heat in the metabolic activities and strong wind flow at this study site.

Conclusion

On the basis of the present research it can be concluded that heat budget at Omkareshwar dam, Maheshwar dam, and Koteshwar dam site may be categorized as one of the example of inefficient or uneconomic heat budget wherein the efficiency of conversion of heat energy towards the biomass and biogenic phenomena is minimum. This is mainly due to excessive evaporation and strong wind currents and its interruption by several submerged rocks reduce the efficiency of utilization of heat energy for biogenic phenomena. These phenomena indicate the ecologically healthy status of the river.

Acknowledgement

Authors are thankful to the Narmada Valley Development Authority, Bhopal (MP) for financial assistance and head of the department of Zoology and Biotechnology Dr. S. C. Kothari for providing laboratory facility.

References

1. Huang G. and Izumiya, Maintaining natural water temperature regime for protecting aquqtic life, *Environmental Systems Research*, **31**, 159–168 **(2003)**

2. Wetzel R.G and Likens G.E., Limnological analysis W.B. Saunders, Co. Philadelphia., 357 **(1979)**

3. Munshi Jayashree Datta and Munshi J.S. Datta, fundamental of freshwater biology, 11 **(1995)**

4. Stewart K.H., Detailed time variations in mean temperatures of some Madison Lakes, *Limnol. Oceanogr*., **18**, 218–225 **(1973)**

5. Crips D.T., Some physical and chemical effects of the cow green (upper teesdale) impoundment, *Freashwater Biol.,* **7,** 109–120 **(1977)**

6. Vivier P., Temperature and dissolved oxygen in deep waters in French artificial reservoirs, *Schweiz. Z. Hydrol.,* **22**, 350–364 **(1960)**

7. Gorham E., Morphometric control of annual heat budgets in temperate lakes, *Limnol. Oceanogr*., **9**, 525–529 **(1964)**

8. Hutchinson G.E., *A treatise on limnology*, 1, John Wiley and Sons, Inc., New York, 10–15 **(1957)**

9. Sreenivasan A., Limnology of tropical impoundments III. Limnology and Productivity of Amravathy reservoir, Madras state, India, *Hydrobiologia.*, **26(3–4)**, 501–516 **(1965)**

10. Sreenivasan A., Limnological studies on Parambikulam Aliyar-Project, I. Aliyar Rwservoir, Madras state, India, Schweiz. Z. *Hydrol.,* **32**, 405–417 **(1970b)**

11. Wetzel R.G., Limnology, Saunders College Publishing, Philadelphia., 743 **(1975)**

12. Soni VK, Limnological studies on Western Zone of Narmada River with special reference to physicochemical regimes, Ph.D. thesis, Vikram University, Ujjain, **(2008)**