© December 2021| IJIRT | Volume 8 Issue 7 | ISSN: 2349-6002

Comparative Analysis of Calorific Values of Lotic Ecosystem of Alaknanda River (Garhwal Himalaya)

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***Abstract* - Calorific value is an important parameter of plants that reflects capacity to fix solar radiation during photosynthesis. Present investigation was carried out in Alaknanda river at Srinagar Garhwal (Uttarakhand), to assess the calorific values in different plant species i.e. phytoplankton, periphyton and aquatic macrophytes of lotic aquatic ecosystem. The calorific values of phytoplankton, periphyton and macrophytes varied from 0.88 kcal gm-1, 1.0 kcal gm-1 and 5.8 kcal gm-1 (minimum) and 6.7, 8.82 and 8.88 (maximum). Low calorific value of phytoplankton, periphyton and macrophytes has been observed during monsoon season in all three years in comparison to other season. While maximum calorific value was observed in Jan-March and last two month (November-December) of the year. Macrophytes were found more effective in maximum calorific value.**

***Index Terms* - Calorific value, Ecosystem, Aquatic, Alaknanda, Phytoplankton, Ecology.**

INTRODUCTION

Calorific value of plants is defined as the amount of heat energy released during combustion of plant tissue. The calorific values of plants are firstly related to physiological characteristics. It is most often and necessary to know the calorific values of living organisms. If the calorific value is determined than biomass can be expressed in energy units, because the basic units of measurements are calorie (Phillipson J, 1966). Thus, the calorie is becoming a generally expected ecological unit, as it gives a better comparison of energy budget and balances for other ecological parameters than number or biomass. Calorific value is an important plant trait because it reflects the photosynthetic ability (gross primary productivity) and nutritional status of plants to some extent (Guan, et al. 2005). Different plant organs (leaf, stem, trunk, and root) have different morphological characteristics and functional traits (Liu, et al. 2018, Niklas, KJ and Enquist, BJ, 2002). Previous studies also showed that the functional properties of plant organs are closely related to their nutrient contents (Jackson, et al.1997). Calorific value can be obtained by burning the sample in a calorimeter and measuring the amount of heat produced. Burning is achieved by combining the two key elements of combustion a fuel and oxygen, at an elevated temperature or an ignition temperature (Jessup, RS 1970). The heat produced at burning is equivalent to calorific content of the oxidized material. For instance, Song, et al. 2016 showed that calorific value and the element content (especially the carbon content) are more strongly correlate some plants, with different functional traits often leads to noticeable differences in element content. However, analysis of energy flow an aquatic ecosystem requires calorific equivalents of its biotic components (Wissing, TE and Hasler, AD 1968). This work presents an experimental study on calorific energy values of biomass residue pellets for heating purposes, because no major research work has been done so far on the calorific values of aquatic plants of Garhwal Himalayas. Therefore, the present investigation on calorific values of aquatic plants has been undertaken.

MATERIALS AND METHODS

Alaknanda River (lotic ecosystem) of Srinagar Garhwal (Uttarakhand) was selected for the present investigation to analyze the calorific value on different biomass. Calorific values of aquatic plants were determined by bomb calorimeter. It is a device to measure the amount of heat generated when matter is burnet in a sealed chamber (Bomb) in an atmosphere of pure oxygen gas. 1.0 gm dried and grind material was compressed into a cylindrical pellet and kept into a crucible. Now a piece of ignition wire was placed across the electrodes within the bomb and 15 cm long sewing cotton thread tied around the ignition wire, and crucible was placed in position so that loose end of the cotton thread were in contact the material. 2 ml. of distil water was poured into the the body of the bomb. After resembling, the bomb was charged slowly with pure oxygen from a cylinder to pressure of 25 atmospheres without displacing its original air. The calorific vessels were filled with sufficient amount of distilled water (approximate 2 liter) to submerge the cover of the bomb to a depth of at least 2 cm leaving the terminal projecting. Now, calorimeter vessels were transferred to the matter jacket and the bomb was lowered carefully into the calorimeter vessel. The bomb terminal was connected with firing unit. The stirrer and Backman thermometer placed accordingly and covered in position and the stirring mechanism was kept in continuous operation at a constant speed during the experiment. The initial constant temperature of the water was determined in thermometer. Now, the bomb was changed from the bomb firing unit. The change of temperature was recorded at equal intervals of 30 seconds until the time after which the rate of change of temperature again become constant.

The bomb was removed from the calorimeter after a lapse of half an hour from the time to firing, to allow the acid mist settled and pressure was released by opening the valve for verifying the complete combustion of the material.

The constant of the bomb were washed out with hot distilled water into a glass beaker and was titrated against 0.1N sodium carbonate solution to determine the acid correction. The water equivalent of the calorimeter was determined as-

$$W = \frac{HM + E_1 + E_2}{T}$$

W= energy equivalent of calorimeter in calories per degree centigrade

H= heat of combustion of standared benzoic acid in calories per gram

M= mass of standared benzoic acid sample in gram

T= corrected temperature rise in degree centigrade

E_1= correction for heat formation of nitric acid, in calories

E_2= correction for heat of combustion of firing wire, in calories

The energy of the sample was calculated as-

$$\text{Energy of sample} = \frac{W \times T-(w+t)}{\text{Weight of sample}}$$

Where,

W= water equivalent

T= corrected temperature rise in ^{0}C

w= calorific value of ignition wire

t= caloric value of thread

RESULTS AND DISCUSSION

Calorific value is an important index for evaluating material cycles and energy conversion in forest ecosystems. The data on the calorific values of phytoplankton, periphyton and aquatic macrophytes have been presented in Fig. 1, 2 & Table 3. The calorific values of phytoplankton varied from 0.88 kcal gm^{-1}, 0.55 kcal gm^{-1} and 0.62 (minimum) to 6.10 kcal gm^{-1}, 5.85 and 6.10 kcal gm^{-1} (maximum) during the first, second and third year respectively (Fig.-1). The maximum calorific values of 8.14 kcal gm^{-1}, 8.09 and 8.82 kcal gm^{-1} and minimum of 1.18 kcal gm^{-1}, 1.00 and 1.10 kcal gm^{-1} of periphyton were recorded during winter and monsoon months in the first, second and third year (Fig. 2). The average mean of phytoplankton and periphyton have been presented in (Table-1). It was recorded maximum in April month 6.21±0.18 while minimum in August month 0.68±0.05 for phytoplankton. Similarly, for periphyton, it was maximum in January 8.35±0.49 and minimum in August month 1.90±0.06. The energy contents of twenty different species of macrophytes ranged from 0.58 kcal gm^{-1} (minimum) to 9.20 kcal gm^{-1} (maximum) during investigation (Table-2). The calorific values determined in all cases for all the samples met the minimum standard requirement for heat energy generation-which ranges from 1500 kcal/kg-1670 kcal/kg according to (Gunther, et al. 2012). Low calorific value was observed during monsoon season in comparison to others. Because the study area has a high solar radiation and lower turbidity during spring season which accounts for a higher value of biomass. When turbidity increases reaching to a maximum value during monsoon season, the solar radiation also diminish except in intense sunshine foe a part of day, biomass is lowest during these months of July and August. Perusal of the data on calorific values of aquatic plants has revealed the values obtained from the bomb calorimetry were higher in comparison to the values obtained from wet oxidation method (Fig. 1, 2 & Table-3). Several studies on calorific value in recent years have proved this prediction. It is well established fact that calorific values of an animal are dependent primarily on the fact and mineral contents of the body (Slobodkin and Richman 1961). The calorific values of phytoplankton recorded from Alaknanda have revealed that it was contributed maximum during March-April (5.46-6.70 kcal gm^{-1}), while minimum during July to August (0.55-2.18 kcal gm^{-1}) in the second year. The same trend of contribution of calorific values of phytoplankton in Alaknanda was observed in the successive year (Fig. 1). Jana and Pal (1982) suggested that results obtained from bomb calorimeter were higher within the range of 3-5% and linear relationship between the calorific values and the chemical composition of the aquatic organism. Winberg, GG (1971) stated that energy contents of aquatic organisms varies between 0.2 to 8.0 kcal gm^{-1}, mainly due to the variations in proportion of mineral to organic fraction. The calorific value varied from parts to parts of plants. The calorific values noticed higher in the Ariel parts of plants in comparison to the root. Similar results also reported by Gao et al. (2012) and suggest that calorific value in the leaf, branch, and other aboveground organs is higher than that in the root. Dowgillo, A (1975) also found the calorific values obtained from wet oxidation method were usually lower than the value of bomb calorimeter by 5-10 percent.

The calorific values of periphyton recorded from Alaknanda have reveled that it was maximum during autumn and winter (8.12-8.18 kcal gm^{-1}) while it was lowest during monsoon season (1.00-1.10 kcal gm^{-1}) in the second and third year. The similar trend in the calorific values of Alaknanda was recorded during the successive year (Fig. 2). High Oxygen content tends to lower the calorific value while high carbon content tends to form high-grade biomass fuel (Ismaila, et al. 2013). Among the aquatic macrophytes maximum energy value was obtained from *Artemisia nilgirica* and the minimum value was found in *Nasturium offinale* (Table-2). The calorific value of *Ajuga biflora*, *A. bracteosa*, *A. contorta*, *Fagopyrum esculanta* and *Vernonica anagallis aquatica* were found to be in higher range. However, *Chenopodium ambrosoides*, *Fumaria indica*, *Ranunculus* spp. and *Staria glauca* have low calorific values. Some other plants like deciduous trees also increase their carbon reserves in shoots during the short growing season, as an adaptation to low temperatures in winter (Horowitz, et al. 2009) and He et al. (2007) reported that the rank order of calorific values for some plant species might have slight differences. The calorific value is the total energy released as heat when a substance undergoes complete combustion with oxygen under standard condition. The different fuels have different calorific values, i.e. different fuels produce different amount of heat on burning.

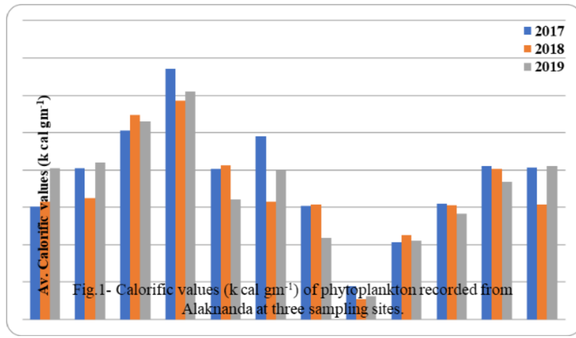

Fig.1- Calorific values (k cal gm^{-1}) of phytoplankton recorded from Alaknanda at three sampling sites.

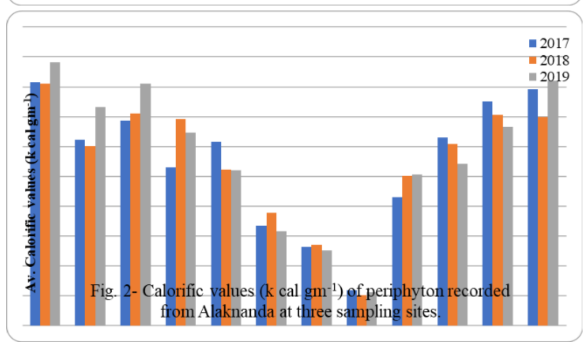

Fig. 2- Calorific values (k cal gm^{-1}) of periphyton recorded from Alaknanda at three sampling sites.

Table-1 Calorific values (kcal gm^{-1}) Average mean: Aquatic phytoplankton and periphyton.

Months	X± S.D.	X± S.D.
Jan	3.40±0.06	8.35±0.49
Feb	3.83±0.68	6.50±0.78
March	5.27±0.12	7.34±0.89
April	6.21±0.18	6.21±0.83
May	3.78±0.66	5.52±0.68
June	4.01±0.60	3.42±0.15
July	2.76±0.64	2.60±0.09
August	0.68±0.05	1.90±0.06
September	2.13±0.10	4.78±0.54
October	2.98±0.17	5.91±0.63
November	3.93±0.24	7.06±0.29
December	3.75±0.73	7.69±0.16

Table-2 Calorific values (kcal gm^{-1}) of aquatic macrophytes recorded from Alaknanda at three sampling sites.

Macrophytes	2017	2018	2019	X± S.D.
Ajuga biflora	7.52	6.10	6.20	6.60±0.81
A. bracteosa	8.75	7.77	8.82	8.44±0.49
Anaphalis cantorta	7.09	6.80	7.25	7.04±0.29
Artemesia niligirica	9.20	9.00	8.68	8.96±0.50
A. scoperia	5.15	6.10	6.00	5.75±0.61
Chenopodium ambrosoides	2.10	2.00	2.25	2.11±0.08

Equisetum arvensis	5.22	6.00	6.10	5.77±0.63
Eupatorium adenophorum	3.70	3.00	2.82	3.17±0.14
Fagopyrum esculanta	8.42	8.00	7.95	8.12±0.45
Fumaria indica	2.14	1.89	1.75	1.92±0.06
Nasturtium officinale	0.80	0.70	0.58	0.69±0.01
Oxalis corniculata	4.70	4.01	4.10	4.27±0.51
Parthenium histerophorum	5.30	5.0	5.05	5.11±0.60
Polygonum barbatum	3.25	2.00	2.95	2.73±0.09
P. capitata	3.02	3.12	3.15	3.09±0.15
Ranunculus spp.	2.20	2.00	2.30	2.16±0.09
Rumex acetosa	2.74	2.01	2.88	2.54±0.09
Setaria glauca	2.05	2.00	2.15	2.06±0.04
Solanum nigrum	4.08	4.06	3.78	3.97±0.19
Veronica anagalis aquatica	8.06	8.08	7.69	7.94±0.39

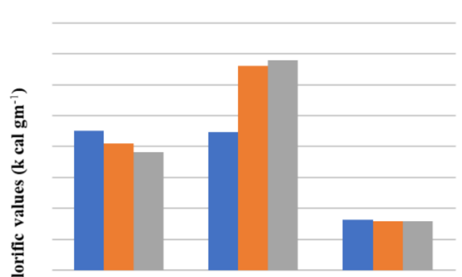

Fig. 3- Av. calorific values (k cal gm^{-1}) of observed plants in different months during 2017-19.

CONCLUSION

The calorific values of aquatic plants were obtained by burning the sample in a calorimeter and measuring the amount of heat produced. The heat produced at burning is equivalent to calorific content of the oxidized material. It is concluded that the entire ecosystem of Alaknanda encountered with many natural (landslide, blockade formation, flashfloods sedimentation) and anthropogenic pressure (deforestation, extraction of sand, pebbles, stones from the catchment area). The factors have direct and indirect impact on the plant diversity of the Alaknanda ecosystem. The conservation and management of aquatic plant diversity of Alaknanda is very important for the efficient energy flow and maintained of the ecosystem and the production of secondary producers including fish.

REFERENCE

[1] Dowgillo A (1975). Chemical composition of an animal's body and of its food. In: Methods for Ecological Bioenergetics, (Eds), *IBP Handbook*. 24:160-186.

[2] Gao K, Song B, Zhu TX (2012). Effects of several factors on plant calorific value based on large-scale conditions. *Pratacultural Science*. 29: 453–458.

[3] Guan LL, Zhou XY, Luo YA (2005). Review on the study of plant calorific value in China. *Chinese Journal of Ecology*. 24: 452–457.

[4] Gunther B, Gebauer K, Barkowski W, Rosenthal M and Bues CT (2012). Calorific value of selected wood species and wood products. *European Journal of Wood and Wood Products*. 70, 755-757.

[5] He X, Bao WK, Gu B, Zheng WJ, Leng L. (2007). The characteristic of gross calorific values of higher plants in China. Ecology and Environment. 16(3): 973−981.

[6] Horowitz ME, Fahey TJ, Yavitt JB, Feldpausch TR (2009). Patterns of late season photosynthate movement in sugar maple saplings. *Canadian Journal of Forest Research*. 39(12):2294–8.

[7] Ismaila A, Zakari IY, Nasiru R, & Tijjani BI (2013). Investigation on biomass briquettes as energy source in relation to their calorific values and measurement of their total carbon and elemental contents for efficient biofuel utilization. *Advances in applied science research*. 4(4): 303-309.

[8] Jackson RB, Mooney HA, Schulze ED. A (1997). Global budget for fine root biomass, surface area, and nutrient contents. *Proceedings of the National Academy of Sciences of the United States of America*. 94:7362–7366.

[9] Jana BB and Pal GP (1982). Energy values of three size groups of Indian and exotic major carps (Pices). *Canadian Society of Zoologists.* 46:194-198.

[10] Liu GW, Pfeifer J, Francisco RD, Emonet A, Stirnemann M, Gubeli C (2018). Changes in the allocation of endogenous strigolactone improve plant biomass production on phosphate-poor soils. *New Phytologist*. 217: 784–798.

[11] Niklas KJ, Enquist BJ (2002). On the vegetative biomass partitioning of seed plant leaves, stems, and roots. *American Naturalist* 159: 482–497.

[12] Phillipson J (1966). Ecological energetic. Arnold publication, London

[13] Jessup RS (1970). Precise measurement of heat combustion with a bomb Calorimeter. U.S.

Bureau of Standards Monograph No. 7, US Government Printing Office, Washington, DC.

[14] Slobodkin LB and Richman S (1961). Calories/gm in species of animals. Nature, 191:299.

[15] Song GY, Hou JH, Li Y, Zhang JH, He NP (2016). Leaf Calorific value from tropical to cold-temperate forests: latitudinal patterns and linkage to productivity. *PLOS ONE*. 6: 3429–3438.

[16] Winberg GG (1971). Methods for the estimation of production of aquatic animals. Academic press London.

[17] Wissing, TE and Hasler, AD (1968). Calorific value of some invertebrates in lake Mendota, Wisconsin. *Canadian Journal Fish Research,* 25(11): 2515-2518.