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A Method for the Estimation of Detritus Energy Generation in Aquatic Habitats

A. Palavesam[1], S. Beena[2], G. Immanuel[2,*]
[1] Department of Zoology, Muslim Arts College, Thiruvithancode, Kanyakumari District, Tamil Nadu, India
[2] Centre for Marine Science and Technology, M.S. University, Rajakkamangalam – 629 502, Kanyakumari District, Tamil Nadu, India

* Corresponding Author: Tel.: + 91 4652 253078; Fax: -
E-mail: g_immas@yahoo.com

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Abstract

Considering the amount of oxygen used for oxidation of detritus organic matter, oxycalorific co-efficient and morphometric feature (Area) of the zones as well as the energy consumed by the dominant detritivores, a method was proposed to estimate the detritus energy generation in aquatic habitats. The conversion of organic matter to energy by oxycalorific co-efficient was also counterchecked by the direct calorimetric energy estimates using Semi-Micro bomb-Calorimeter. The difference between direct estimate and estimate by oxycalorific co-efficient conversion was not statistically significant (“t” test, $P > 0.05$).

Key Words: Energy, Aquatic habitats, Detritus, Biomass

Introduction

Ecological energetics is a useful approach for assessing the importance of different species and their contribution to the structure, productivity and function of community (McDiffett, 1979). The complexity of the environment, the fluctuating environmental factors and the diversity of fauna and flora as well as the non-availability of simple method have forced ecologists either to choose a simple environment for the estimation of energy transfer from one trophic level to another (Engelmann, 1969) or to study the productivity of key species in the complex environment (Odum and Smalley, 1959; Paine, 1971). In Wetlands, the high level of primary production ensures the entry of a significant fraction of primary productivity as detritus energy source (Davis and Wanerwalk, 1978, Palavesam, 1991). However, the contribution of terrestrial run off and leaf litter for detritus generation cannot be ignored. At times of low endogenous primary production aquatic primary consumers derive about 66 to 76 % of their energy requirement from the detritus imported into the habitat through terrestrial run off and leaf litters (Teal, 1957). Odum (1959) found that despite highly stable environment conditions in Silver Spring, Florida, energy flow through detritus food chain is greater than that through producer – grazer food chain. Teal (1957) also reported a similar situation in the root spring. Considering the importance of detritus energy generation in ecological energetic as well as the paucity of information on detritus energy generation, a method was developed in order to study the detritus energy generation in aquatic habitats.

Material and Methods

In the present study, for the aim of estimating the detritus energy generation, a tropical pond was selected as a model habitat. Morphometric features (zones) of the selected pond were measured and the area was calculated following the gravimetric method of Welch (1948). Considering the morphometric features, two zones viz., Littoral and Sub-littoral zones were marked in the selected pond and the area of respective zone was also calculated.

Sediment Sampling

Sediment samples from a known area (10 cm^2) of the selected zones were collected up to a depth of 8 to 10 cm and the total organic matter was analyzed after removing the benthic biomass completely. By relating the area of the zone in the respective sampling month with that of the average organic matter in 10 cm^2 areas, the total organic matter in that zone was calculated. Total organic matter content in the sampled sediment was estimated following the rapid titration method of Walkley and Block (1934). For the conversion of detritus organic matter into energy density, the oxycalorific co-efficient proposed by Winberg (1971) was used i.e., 1 mg O_2 used for the oxidation of detritus organic matter is equal to 14.23 J energy.

Biomass Sampling

In the chosen zones of the experimental pond, the dominant detritivore population (*K. barbitarsis*) was measured by using a wooden quadrant 30 x 30 x

30 cm (Length x Height x Breadth). The quadrant was placed at random in the selected sites of littoral (0 to 15 cm depth) and sub-littoral zones (15 to 30 cm depth) of the experimental pond. From each zone, 5 to 7 samples were collected and brought to the laboratory. Then the samples were sieved through 0.2 mm sieve and the larvae of *K. barbitarsis* were segregated into four groups based on their length i.e., 0 to 5, 5 to 10, 10 to 15 and 15 to 20 mm. With least disturbance, the larvae in each group were counted, weighted and released into the same area of the pond. Biomass of the detritivore (*K. barbitaris*) was calculated by multiplying the weight of each group (g) by the total number of larvae in the respective group and expressed as g/m^2. Larval biomass from the respective zone was grouped together and the average biomass (g/m^2) was calculated for each zone separately. The bottom sample consisted of chironomid larvae (95%), dragonfly and damselfly nymphs (3%) and other aquatic beetle larvae (2%). Since the contribution of chironomid larval population was more than 90% of the total detritivore population its consumption was used for the calculation of detritus energy loss (De Loss).

Detritus Consumption

To begin with, by relating gut loading time, gut clearance time and gut content weight of the respective larval stages of dominant detritivore *K. barbitarsis*, detritus consumption was calculated by following the method described by Muthukrishnan and Palavesam (1992). Detritus consumption rate by the selected weight groups of larvae was calculated by relating the quantity of food ingested, with the weight of the respective larval stage. For instance, 0.5 cm *K. barbitarsis* larva weighing 0.80 mg ingested 1.397 mg food per day. Detritus consumption rate (mg detritus / mg larva/day) was calculated by dividing the amount of the detritus ingested (mg/larva/day) by the larval weight (0.80 mg) i.e., 1.397/0.80 = 1.75 mg/mg larva/day. Considering the energy content of the detritus matter, the food consumption rate was converted into J/mg larva / day. Then by relating the laboratory estimate of food consumption (J/mg larva /day) with that of the respective size group of field biomass; total detritus energy consumed by this dominant detritivore in field condition for a set duration of time was calculated.

Results

Detritus Generation

Basic data used for the estimation of detritus energy generation (KJ/m^2) in chosen pond during first and succeeding second month are given below (Table 1 and 2).

Amount of organic matter present in the selected zones in chosen pond during first and succeeding month was 427.4 and 336.9 KJ/m^2 (i.e. $1E_1$ and $1E_2$) and 759.9 and 606.5 KJ/m^2 (i.e. $2E_1$ and $2E_2$) (Table 1).

The area covered by the zones during first month was 60.0 and 47.2 m^2 (i.e. a and b). To calculate the total amount of detritus energy generated in each

Table 1. Area and detritus organic matter in the selected zones of the experimental pond

Sampling Period / Zone of the Pond	Area (m^2)	Detritus Organic matter		Energy (KJ/m^2)
		Energy (J/mg)	Dry weight (g/m^2)	
First Month				
Littoral Zone (Zone A)	60.10(a)	5.41*	79	427.4 ($1E_1$)
Sub-littoral Zone (Zone B)	47.2(b)	4.06*	83	336.9 ($1E_2$)
Succeeding Second Month				
Littoral Zone (Zone A)	47.0(2a)	6.28*	121	759.9 ($2E_1$)
Sub-littoral Zone (Zone B)	39.4(2b)	5.14*	118	606.5 ($2E_2$)

* For the conversion of detritus organic matter into detritus energy, the oxycalorific co-efficient (1 mgO_2 used for the oxidation of detritus organic matter is equal to 14.23J energy) proposed by Winberg (1971) was used.

Table 2. Biomass and detritus energy consumption by dominant detritivore larvae (*K. barbitarsis*) in the selected zones of the experimental pond

Sampling period (months)	Area of the Pond			
	Littoral Zone		Sub-littoral Zone	
	Biomass (g/m^2)	Detritus Consumption Rate (KJ/m^2)	Biomass (g/m^2)	Detritus Consumption Rate (KJ/m^2)
First Month	14.21	95.50 (aDE)	3.75	18.86 (bDE)
Second Month	18.70	94.44 (a_1DE)	8.20	26.93 (b_1DE)

zone, the amount of organic matter in each zone i.e., $1E_1$ and $1E_2$ was multiplied by the corresponding area of zones i.e., a and b (a x $1E_1$ = a$1E_1$ and b x $1E_2$ = b$1E_2$). Average detritus energy (KJ/m^2) available in zone A and B was calculated by dividing the total organic matter present in the respective Zones by the total area of the zones (a$1E_1$ + b$1E_2$ / a + b). Then by subtracting the amount of detritus energy loss due to consumption by the dominant detritivore population (i.e. aDE and bDE) from the detritus energy available in each zone (i.e. a_1E_1 and b_1E_2), the amount of detritus carried over to the succeeding second month in zones A and B was calculated (i.e. a_1E_1 – aDE = aDEC and b_1E_2 – bDE = bDEC). Amount of detritus energy available in the succeeding second month was 759.9 and 606.5 KJ/m^2 (i.e. $2E_1$ and $2E_2$). The detritus energy generated in the succeeding second month was calculated by subtracting the detritus energy carried over from the first month (i.e. aDEC and bDEC) from the detritus energy available (i.e. $2E_1$ and $2E_2$) in second month ($2E_1$ – aDEC = aDEG and $2E_2$ – bDEC = bDEG). Area covered by selected zones in second month was 47.0 and 39.4 (i.e. 2a and 2b). Total amount of detritus energy generation in each zone during the succeeding second month was calculated by multiplying the detritus energy generated in each zone. (i.e., aDEG and bDEG) by the corresponding area of zones (i.e. 2a x aDEG =2aDEG and 2b x bDEG = 2bDEG). The average detritus energy generation (KJ/m^2) during succeeding second month was calculated by diving the total detritus energy generation (i.e. 2aDEG + 2bDEG) by the total area of zones (2a + 2b) (i.e. 2aDEG + 2bDEG / 2a + 2b).

Calculations

Total Area of each zone during first month

Zone A = a (60.0m^2)
Zone B = b (47.2m^2)

Total Detritus energy generated in each zone

Zone A = a x $1E_1$ = (a_1E_1) : (60.0 x 427.4)
= 25644.00 KJ

Zone B = b x $1E_2$ = (b_1E_1) : (47.2 x 336.9)
= 15901.70 KJ

Average detritus energy (ADE) available in the selected zones (zone A and zone B) during first month

ADE = (a_1E_1 + b_1E_2) / (a + b)
= (25644.00 + 15901.70) / (60 + 47.2)
= 387.55 KJ/m^2

Detritus Energy (DE) loss in zone A = 95.51 KJ/m^2 (aDE)**

Detritus Energy (DE) loss in zone B = 18.86 KJ/m^2 (bDE)**

** DE loss in each zone was calculated by correlating laboratory estimate of food consumption with the field biomass of the respective zones (Table 1).

DE carried over in Zone A (aDEC) = a$1E_1$ – aDE
= (427.4*** – 95.51)
= 331.9 KJ/m^2

DE carried over in Zone B (bDEC) = b$1E_1$ – bDE
= (336.9*** – 18.86)
= 318.0 KJ/m^2

*** J/m^2 in each zone was calculated by dividing by a_1E_1/a and b_1E_2/b, respectively.

Detritus Energy Generation (DEG) during the succeeding second month

Zone A (aDEG) = $2E_1$ – aDEC (759.9 – 331.9)
= 428.0 KJ/m^2

Zone B (bDEG) = $2E_2$ – bDEC (606.5 – 318.0)
= 228.5 KJ/m^2

Total area of succeeding second month

Zone A = 47.0 m^2 (2a)

Zone B = 39.9 m^2 (2b)

Total Detritus energy generated in each zone

Zone A (2aDEG) = 2a x aDEG (47.0 x 428.0
= 20116.0 KJ)

Zone B (2bDEG) = 2b x bDEG (39.4 x 228.5
= 9002.9 KJ)

Average detritus energy generated during succeeding second month

(Average) = 2aDEG + 2bDEG / 2a + 2b
= 20116.0 + 9002.9 / 47.0 + 39.4
= 337.02 KJ /m^2

Discussion

According to this proposed method, the total detritus energy generation in zone A and zone B of the chosen model tropical pond during the first month was 25644.00 and 15901.70 KJ, respectively. During this period, the average detritus energy generation was 387.55KJ/m^2. In these zones, the total detritus energy available after deducting the detritus energy loss through consumption by the dominant detritivore population (95.5 KJ/m^2 in zone A and 18.86 KJ/m^2 in zone B) was 331.90 KJ/m^2 (zone A) and 318.0 KJ/m^2 (zone B). This is the detritus energy available to carry over for the succeeding month from the respective zones. In the succeeding month, the detritus energy generated in zone A and zone B was 428.0 and 228.5 KJ/m^2, respectively. And these values were obtained after subtracting detritus energy carried over from the previous month. The total energy then available in zone A and B was 20116.0 and 9002.90 KJ, respectively with an average value of 337.02 KJ/m^2. By employing this proposed method, the total and average detritus energy generated in the zone A and zone B of the tropical pond was estimated. This proposed method would be of much applicable help in quantifying the detritus energy generation in productive aquatic habitats.

To test the validity of the proposed method, the energy content of the sediment was also estimated calorimetrically using semi-micro bomb-calorimeter and the data are provided in Table 3. The energy density of the sediment estimated by both methods was very closer and the difference between them was not significant ("t" test; P > 0.05).

Table 3. Energy density of the sediment (J/mg) in the selected zones of the tropical pond Each value (Mean ± SD) is the mean of three estimates

Habitats	Methods	
	Calorimetric method	Oxycalorific conversion method
Littoral Zone	5.50 ± 0.35	5.41 ± 0.40*
Sub-littoral zone	4.25 ± 0.20	4.06 ± 0.25*

*Statistically not significant ('t' test, P > 0.05)

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