ISSN 2582 – 6050

Available Online at www.ijpba.info
International Journal of Pharmaceutical & Biological Archives 2024; 15(3):82-88

RESEARCH ARTICLE

Some Ecological Studies of Detritus as a Major Component of Lotic Ecosystem

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Received: 29 May 2024; Revised: 20 July 2024; Accepted: 30 July 2024

ABSTRACT

Introduction: Detritus, the decomposing organic matter found in lotic (flowing water) ecosystems, plays a critical role in supporting biodiversity and ecosystem function. It serves as a primary energy source for many organisms within these ecosystems, influencing nutrient cycling and food webs. This abstract summarizes recent ecological studies on the significance of detritus in lotic environments. **Role of Detritus in Lotic Ecosystems:** Ecologists now believe that particulate detritus is the food resource that supports, directly or indirectly, well over half the animal production in most ecosystems. Most animals wait until plants die and partly decompose before using this material food. Invertebrates such as shredders, collectors, and detritivores rely on detritus as a food source, while microorganisms decompose it into simpler compounds, contributing to nutrient cycling. Studies have shown that the quality and quantity of detritus are influenced by factors such as vegetation cover, hydrology, and land use (Wallace et al., 1997; Graça et al., 2001). This interaction supports a complex food web, with primary producers and consumers depending on the energy and nutrients released from detritus. **Detritus Decomposition and Ecosystem Function:** At Station 1, the minimum quantum (0.012 g/m2) of the dry detritus was recorded in August, 2022; whereas the maximum (0.363 2 g/m2) in April, 2022 during the first year. In the second year, the minimum (0.027 g/m2) was observed in September, 2023 and maximum (0.568 g/m2) during January, 2023. At Station 2, the dry detrital content was slightly higher as compared to Station 1: but the quantum of variation showed similar seasonality, at both the lolic stations, in which (0.043 g/m2) was recorded in August and highest (0.782 g/m2) in March, during the first year. In the second year the minimum detrital content (0.0:36 2 g/m2) was observed in September, 2023 and the maximum (0.331 g/m2) in January, 2023. **Conclusion:** Detritus is a crucial component of lotic ecosystems, influencing energy flow, nutrient dynamics, and biodiversity. Understanding its role in ecosystem processes is essential for managing freshwater habitats and mitigating the impacts of human activities on these environments.

Keywords: Aquatic productivity, biodetritus, detritus, microbial decay, etc.

INTRODUCTION

Detritus is dead organic matter, develops when organic material is decomposed, particularly in soils and aquatic environments.[1] The organic detritus or biodetritus which was described by Odum and de la Cruz (1963) are dead particulate organic matter inhabited by decomposer microorganisms (Wetzel, 1982).[2] Thus, detritus may be defined as consisting of both the non-living leaf debris and the associated living microorganisms.[3] The process forming detritus from leaves include fragmentation, mechanical breakdown by physical or biological grinding, autolysis the release of cell contents due to the action of plants enzyme, leaching, the removal of water soluble components and microbial decay, digestion of the debris by bacterial or fungal extracellular enzymes.[4] The combined effect of these processes in reducing particulate detritus to a sub particulate form is

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called decomposition. In freshwater ecology the study of detritivores has been concerned less with the size of the organisms than with the ways in which they obtain their food.[5,6] Cummins (1974) devised a detritivores that feed on coarse particulate organic matter (particles >2 mm in size), and that recognizes four main categories of invertebrate consumer in streams.[7] Shredders are using feeding these serve to fragment the material. Very often in streams, the shredders, such as cased caddisfly larvae, freshwater shrimps and isopods, feed on tree leaves that fall into the stream. Collectors feed on fine particulate organic matter (<2 mm). Collector-gatherers obtain dead organic particles from the debris and sediments on the bed of the stream, whereas collector-filterers sift small particles from the flowing column of water.[9] Grazer-scrapers have mouthparts appropriate for scraping off and consuming the organic layer attached to rocks and stones; this organic layer is comprised of attached algae, bacteria, fungi, and dead organic matter adsorbed to the substrate surface. The final invertebrate category is carnivores.[10]

Ecologists have long recognized its contribution to aquatic productivity.[11] Thus the biological degradation basically involves reduction of the particulate organic bodies through a continuous process in which the large particles are reduced in size, which ultimately solubilizes in water, usually, affords a rich source of nutrients for aquatic organisms and a mechanism for rapid recycling of nutrients released upon death of plants or breakdown of waste products.[12] Pimm (1982) described the relationship that generally exists between decomposers or detritivores and their food as donor controlled: the donor (prey; i.e., dead organic matter) controls the density of the recipient (predator, i.e., decomposer or detritivore) but not the reverse.[13] This is fundamentally different from truly interactive predator-prey interactions. Indeed, while there is generally no direct negative feedback between decomposers/detritivores and the dead matter consumed (and thus donor-controlled dynamics apply), it is possible to see an indirect, positive "mutualistic" effect through the release of nutrients from decomposing litter, which may ultimately increase the rate at which trees produce more litter.[14] In fact, it is in nutrient recycling that decomposers and detritivores play their most fundamental role in ecosystems.[15] In other respects, of course, the food webs associated with decomposition are just like food webs based on living plants: they have a number of trophic levels, including predators of decomposers and detritivores, and consumers of these predators, and thus they exhibit a range of trophic interactions (not just donor controlled).[16,17]

However, the interrelationships between such heterotrophic food chains and autotrophic food chains are poorly understood.[18] Because detritus is a complex mixture of various types of organic matter, its composition is variable, depending upon its derivation.[19] Although dead animals may make some little contribution, most detritus appears to be derived from plants (Parsons and Tinsley, 1975). Detritus is found in all aquatic habitats, a large portion of the particulate matter suspended in both standing and flowing water.[20]

The suspended detritus consists of particles of fine silt and sand, around which organic matter and bacteria adhere and form aggregates of different shapes and sizes. The other constituents of detritus are the fecal pellets, and a variety of recognizable remains of plants and animals. Bacteria appear to be the most important.[21] In addition to production of new bacterial cells, bacteria uses dissolved organic matter to produce extracellular organic matrix (Hobbie and Lee, 1980; Costerion *et al*., 1931).[22]

Ecologists now believe that particulate detritus is the food resource that supports, directly or indirectly, well over half the animal production in most ecosystems. Most animals wait until plants die and partly decompose before using this material food (Wetzel, 1975).[23]

Limnologists have long recognized detrital contribution to aquatic productivity, but aquatic detrital food chains have been largely restricted to fundamental research, very little attempt has been directed to their importance in aquatic ecosystem. The interpretations of the role of detrilus in an aquatic ecosystem have changed considerably in course of time. Significant stages of these changes were: The Lindeman's (1942) concept of "Qoze" and more recently "Biodetritus" defined by Odum and de la Cruz (1963), Wetzel *et al*. (1972), Wetzel and Rich (1973), Rích and Wetzel (1978) defined detritus as non-predatory losses of organic carbon from any trophic level, but they do not distinguish between particulate and dissolved organic matter. This definition is now being commonly used in most of the limnological literature.[24]

In general, detritus is a substrate for bacterial growth, a main food for many animals and it plays an important role in the modification of habitat structure. Aquatic macrophytes are the main source of detritus, but a large part of detritus enters also from land mainly in the form of leaf litter.[25]

The review of the literature shows that in the majority of cases, the studies on detritus are mainly concerned with the' productivity and to some extent dealt with the pool organic matter. As an example, MacGinilic (1935) have stressed the importance of particulate organic detritus in the United State and Europe. Odum and de la Cruz (1943) worked organic detritus which was of dead particulate organic matter inhabited by decomposer micro-organisms. Several authors have studied the detritus of fish ponds in Czechoslovakia (Straskroba *et al*., 1970; Dykyjova and Kvet, 1978), Lake Neusiedlar in Austria (Imhof and Burian, 1972; Loffler, 1979), Lake Lawrence in U.S.A. (Wetzel and Allen, 1972; Wetzel and Rich, 1973), Lake Globokoe in the Soviet Union (Secrbakov, 1967), Masurinan in Poland (Pieczynska *et al*., 1984). Many workers have emphasized the importance of organic detritus as food of benthic animals and some Fishes (Darnell, 1967; Parsons and Tinsely, 1975; Mailingle *et al*., 1981; Lopez and Cheng, 1982; Miller *et al*., 1984; Taghon and Jumars, 1984). Odum (1962, as 63) has clearly emphasized that detritus originating as ungrazed primary production supports a detritus food chain which is essentially parallel to the conventional grazer food chain at succeeding trophic levels. Measures of detritus organic matter content have been used as approximations to energy assimilation (Lopez and Cheng, 1982). Besides this, particular kinds of detritus, and their occurrence, composition or processing were examined in greater detail by Anderson and Macfadyen (1976), Godshalk and Wetzel (1978), Kolodziejezyk (1980), LeCren and MaConnel (1980).

During the past two decade, a number of important scientific papers have appeared dealing with the topic of biological decomposition, consumption, ingestion, and utilization of the particulate organic detritus.[26]

In India, the dead organic detritus of aquatic system have not received much attention as compared to those of other biotic forms. The quantitative estimation of settled detritus in India was perhaps for the first time estimated by Qasim *et al*., (1969) and Qasim and Sankranarayanan (1972) in Cochin back waters. They also estimated the quantitative aspect of large fall out of plant and animal material in the same water body. Now a days the study of organic detritus has just entered the analytical phase.

The estimation of the rates and importance of autochthonous primary production in the aquatic ecosystem by the attached. Benthic algae and larger aquatic plants are very difficult. The allochthonous sources of organic matter to aquatic system are primarily of terrestrial origin from photosynthetic production. The particulate organic matter mostly of plant origin fall directly into the water bodies from overhanging canopies, be transported by runoff water or be wind blown into the water. The foliage from trees and ground vegetation provide very significant inputs of organic matter to lentic and lolic water system. Leaf litter fall and the wind-blown detrital material have significant role in aquatic ecosystem but generally this input is small.

Considering the tremendous amount of organic matter which annually passes through the processes of biological decomposition in an aquatic ecosystem and recognizing the existence of a number of dependent communities which received energy from no other source except detritus. This unexplored field must stand as one of the major frontiers of the aquatic science. With this idea in view, the present study was undertaken in the case of lentic and lotic water bodies, Patna (Bihar) India. The seasonal changes in the input of dry organic detritus and their energy values are depicted in Table 1. During the present

Table 1: Dry weight (g/m²) and energy content (Kcal/m²) of detrital matter at lotic stations

Year with months	Station: 1		Station: 2	
	g/m²	Kcal/m²	g/m²	Kcal/m²
2021				
October	0.216	0893.39	03142	304.30
November	0.343	1722.02	0.5273	652.98
December	0.135	0758.83	0.650	3671.36
2022				
January	0.277	1721.32	0.457	2843.26
February	0.166	0956.72	0.402	2323.68
March	0.122	0536.34	0.783	3460.73
April	0.364	1651.14	0.570	2587.57
May	0.298	1346.57	0.615	792.13
June	0.258	1084.35	0.594	2495.17
July	0.114	0365.25	0.227	0729.50
August	0.013	0035.68	0.044	0125.24
September	0.036	0122.52	0.068	0227.16
October	0.074	0313.99	0.180	0743.97
November	0.217	1087.97	0.447	2245.37
December	0.383	2161.36	0.68	3801.44
2023				
January	0.569	3541.35	0.832	5180.63
February	0.157	0904.59	0.357	2080.46
March	0.192	0846.03	0.502	217.53
April	0.260	1178.36	0.368	1678.41
May	0.368	1747.42	0.713	3381.13
June	0.440	1844.81	0.550	2734.21
July	0.044	0139.62	0.066	0210.53
August	0.072	0206.13	0.072	0243.91
September	0.026	008540	0.014	0122.52

investigation, the detrital contents showed a wide range of fluctuations in both lotic stations in the River Ganga at Hajipur, Bihar.

MATERIALS AND METHODS

The decaying leaf litters, twigs and other decaying organic matters were collected with the help of Ekman's dredge (15.2 × 15.2 cm) from both stations of the Ganga river at Hajipur, Bihar. The dredge materials containing the detrital mass along with the benthic macroinvertebrates were sifted through the size 40 no. Sieved and was then transferred to an enamel tray. The benthic organisms were picked up manually and the leaf toner crude detritus in the enamel tray was again sifted to remove the adhered sand and particles. The detritus was the transferred on the blotting paper for removing the extra water. The wet weight of the detritus was then taken and it was kept in an oven at 60°C for 24 h. Energy After taking the wet weight of the macrophytes benthic macroinvertebrate and detritus, there were kept in an oven at 60°C for 24 h. The dry weight was then taken and carbon content of these biotic components were estimated by wet oxidation method following Quasim and Jacob (1972) and the caloric value were calculated from its carbon content by using the equation given by Platt *et al*. (1969).

RESULTS AND DISCUSSION

At Station 1, the minimum quantum (0.012 g/m^2) of the dry detritus was recorded in August, 2022; whereas the maximum (0.363 2 g/m^2) in April 2022, during the 1st year. In the 2nd year, the minimum (0.027 g/m^2) was observed in September 2023 and maximum (0.568 g/m^2) during January 2023.

At Station 2, the dry detrital content was slightly higher as compared to Station 1: However, the quantum of variation showed similar seasonality, at both the lolic stations, in which (0.043 g/m^2) was recorded in August and highest (0.782 g/m^2) in March, during the 1st year. In the 2nd year, the minimum detrital content (0.0:36 2 g/m^2) was observed in September 2023 and the maximum (0.331 g/m^2) in January 2023

The natural water bodies are supplied with detritus of various origin, hydrophytes are the main source of detritus which are produced in situ, in spite of this a large part of detritus also enters to the water body from land, mainly in the form of leaf litter. The kinds of detritus may differ considerably, which may come from the different vegetational sources, such as autochthonous sources phytoplankton, marginal submerged vegetation and periphyton growing on stems of emergent plants. The seasonal variability in the intensity of detritus formation from hydrophytes depends on their phenology, decomposition rate and dynamics of their utilization by animals. Allochthonous sources marginal vegetation and leaf litter washed storm and rain from the catchment areas. Results contribution of many investigators prove the significant of leaf litter in cycling of organic matter in small streams, which decreases in larger running walers (Minshall, 1967; Kaushik and Hynes, 1971; Cummins *et al*., 1972,73; De la Cruz and post, 1977; Lecren and MaConnell, 1980).

Pimm (1982) described the relationship that generally exists between decomposers or detritivores and their food as donor controlled: The donor (prey; i.e., dead organic matter) controls the density of the recipient (predator, i.e., decomposer or detritivore) but not the reverse. This is fundamentally different from truly interactive predator-prey interactions. Indeed, while there is generally no direct negative feedback between decomposers/detritivores and the dead matter consumed (and thus donor-controlled dynamics apply), it is possible to see an indirect, positive "mutualistic" effect through the release of nutrients from decomposing litter, which may ultimately increase the rate at which trees produce more litter. In fact, it is in nutrient recycling that decomposers and detritivores play their most fundamental role in ecosystems. In other respects, of course, the food webs associated with decomposition are just like food webs based on living plants: They have a number of trophic levels, including predators of decomposers and detritivores, and consumers of these predators, and thus they exhibit a range of trophic interactions (not just donor controlled).

During the present investigation, it was observed that the allochthonous detritus input in the form of falling fragments of terrestrial plants constitute the major constituent of detrital mass. Fisher and Likens (1973) estimated that airborne input of organic matter, mostly leaves, may constitute more than 40% of the total input of organic matter to stream ecosystem. Besides this, results of many Investigators indicate allochthonous detritus input into various water bodies, including Gasith and Hasle (1976), Rau (1976), Gasith and Lawacz (1976), Odum and Prentki (1978), Lecren and MaConnell (1980). The present study confirms the findings of the above workers, as the allochthonous input constituted the major source of organic detritus in the aquatic ecosystem. In the present data, detrital matter exhibited a clear differences between the both lotic stations. It is probable that the allochthonous source of detritus depends on the degree of vegetation of the areas directly adjacent to the water body or along the river course. The appreciable differences of the detrital mass between Station I and II may probably be due to the water movements and the effects of substratum result in a uniform distribution of different detritus types. Gradients of flow velocity and turbulence further separate particles flowing waters according to size and density (Hynes, 1970).

In the present data, it is evident that the detrital contents was generally high at Station 2, which could be attributed organic matter - sewage source of allochthonous at all the two stations the plant remains dominated and it was observed that covering the upper few millimeters of the sediment largely contain settled detritus. These detrital mass showed somewhat definite seasonality, as the highest dry mass was found in early summer during the 1st year, while during winter in the 2nd year, the lowest detritus quantum on the bottom was observed during monsoon months. The highest settlement of detritus during early summer months could be attributed to the falling of leaf from the trees and transportation to the waterbody by wind and storm action, hence more detrital matter. The next higher value of the detritai utter could be attributed to the bacterial decomposition of the leaf litter and may be due to low water Temperature; hence, solubilization of the organic carbon into DOM was minimum. The present data also support the low content of DOM during the same period. The lowest dry detrital mass was observed during the monsoon months which could be attributed to the accelerated action of the bacteria on the detrital matter, breaking down the larger detrital matter into simpler ones and finally into the DOM. The actual estimates of the transport of airborne fall into water system are scarce and highly variable, under favorable environmental conditions allochthonous materials increases with the catchment area (Ohle, 1965; Wetzel and Olsuki, 1974). Szczepanki reported an annual transport of 500 g of dry leaves per meter in lake at Poland. Levenidov (qualed by Kaushik and Hynes, estimated an annual input of 500 g/m^2 of leaves into lakes. Fisher and Likens

(1973) reported the autumn leaf litter input to Bear Brook in New Hampshire was 305 g/m^2. McDowell and Fisher (1976) estimated the total litter input to the stream ecosystem during the 77 days study period was 345 g/m^2. The stream studied by them were located in the midst of sense forest, hence the total detrital matter was much higher as compared to the present study. The present study areas are located in a densely populated place; having a small catchment area. The rooted vegetation and trees are scarce. Thus, and the airborne litter fall input is much less as compared to the above workers. Teal (quoted by Kormondy, 1984) evaluated the total energy Input and concluded that the photosynthesis accounts for 710 kcaL/m^2/year. On the contrary, terrestrial plant falling oп the spring accounted for 2350 kcaL/m^2/year. Thus, the lotic environment most of the energy supporting the higher trophic level is neither produced within the system nor derived from the living material. The investigator is of the opinion that in the tropical water bodies with plenty of sunshine and more duration of sunshine hours the energy input in most of the water bodies are largely of external origin in the form of detritus which plays a major role in the trophic dynamics of the aquatic ecosystem. Hence, any estimate of biomass production of an aquatic body without taking into account the input of allochthonous as well as autochthonous input of organic material which contributes in the productivity of any water will be incomplete without considering the quantum of detrital energy which are the major sources of energy income.

CONCLUSION

Detritus is a vital component of lotic ecosystems, driving nutrient cycling, energy flow, and habitat complexity. Studies emphasize its role in supporting aquatic biodiversity through microbial decomposition and as a food source for detritivores. Factors such as hydrology, vegetation, and human activities influence detritus dynamics, impacting ecosystem health. Protecting detritus processes is essential for maintaining the ecological balance and sustainability of freshwater systems amidst increasing environmental challenges.

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