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Molluscan Community: A Potential Sink of Carbon

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Abstract

Stored carbon in dominant molluscan species collected from three regions of the Indian subcontinent (Hooghly estuary in West Bengal, Mandovi estuary in Goa and Kalapet coast in Puducherry) was analyzed both in shell and flesh. The accumulation was more in the flesh (~35%) compared to the shell (~12%) irrespective of stations, seasons and species. Pronounced spatial variation of stored carbon was observed, which confirms the role of environmental variables on carbon storage.

Keywords: *Indian coast, molluscs, stored carbon*

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INTRODUCTION

The coastal and estuarine regions of Goa, Puducherry and West Bengal are rich beds of several species of gastropods and bivalves. These shelled organisms are both mobile and sedentary in nature and depend on phytoplankton, algal mat and detritus for their nutrition. *Saccostrea cucullata*, a dominant sedentary bivalve is common in almost all the coastal zones of Indian subcontinent. It is a filter-feeding bivalve and obtains carbon from phytoplankton. The gastropods are also the store house of carbon as evidenced from the concentrations of total carbon (% dry weight) in their soft tissues and shells [1]. One of the most important sources of carbon in marine and estuarine gastropods is their diets, which mainly is macroalgae or seaweeds on the mangrove vegetation (preferably on mangrove trunk/stem) and detritus on the intertidal mudflats. However, the food preference is species-specific. *Cerithedia obtusa* is fully dependent on algal matter for nutrition and *Nerita articulate* prefers both algal feed as well as detritus. *Telescopium telescopium* and *Cerithedia cingulata* are purely detritivores.

Depending on the food availability, population density and biomass of gastropods and bivalves in the intertidal areas of tropical estuaries exhibit pronounced variation. The population densities of *C. cingulata* and *T. telescopium* are more in the detritus-rich intertidal mudflats, whereas *C. obtusa* are mostly sighted on the mangrove trunks and pneumatophores covered with macroalgae. All these food sources are rich reservoir of carbon [2, 3]. It is, therefore, important to evaluate the potential of molluscan community as sink of carbon. The present study is a snapshot toward this direction. The bivalves (preferably oyster) and gastropods are widely distributed in the intertidal areas of Goa, Puducherry and West Bengal and they prefer variety of diet. It is presumed that diet may be one of the criteria for inter-specific variation of stored carbon. In this study, focus has been given on four widely distributed dominant gastropod species, namely, *T. telescopium*, *C. obtusa*, *C. cingulata* and *N. articulata* along with the most common bivalve species *S. cucullata* for estimating the stored carbon (in percentage) in their flesh and outermost calcareous shell. Considering the background of carbon dioxide rise in the atmosphere and carbon storage potentials of gastropod and bivalve in the coastal and estuarine zones, the present paper aims to estimate stored carbon in calcareous shell and soft tissue of dominant molluscan species inhabiting the selected stations of the coastal and estuarine zones.

MATERIALS AND METHODS

Sampling

The present study was carried out during May 2014 to April 2015 in the intertidal mudflats selected in two maritime states and one Union Territory of India, namely, West Bengal (Hooghly estuary in Sundarbans), Puducherry (Kalapet coast) and Goa (Mandovi estuary). The population of molluscan species was estimated in fifty quadrates (of dimension 1 m×1 m) per station in order to evaluate the most dominant species on the basis of relative abundance. The molluscs were handpicked, collected and brought to the laboratory. The molluscan specimens were cleaned, photographed and finally preserved in 4% formalin. The standard literature of Zoological Survey of India (ZSI) [4] was used for identification of the molluscan species.

Analysis of Stored Carbon

The collected gastropods and bivalves were washed with double-distilled water. Soft tissues were separated from shells and both (soft mass and shell) were dried separately to a constant weight and homogenized in an agate mortar. 15 samples of the soft tissues and shells from each species were mixed thoroughly by grinding. The concentrations of carbon were determined in samples of the soft tissues and shells by means of a CHN-apparatus (Type 1108, Carlo Erba Instruments).

RESULTS

The stored carbon percentages in the soft tissues of the dominant molluscan species inhabiting the selected sampling stations are presented in Figures 1–3. In *T. telescopium* flesh, the stored carbon ranged from 33.90±0.74% (in the Kalapet coast of Puducherry during monsoon) to 36.02±0.63% (in the Hooghly estuary of West Bengal Sundarbans during premonsoon). In the flesh of *N. articulata*, the stored carbon ranged from 32.49±0.74% (in the Kalapet coast of Puducherry during monsoon) to 36.99±0.64% (in the Hooghly estuary of West Bengal Sundarbans during premonsoon). In the flesh of *C. cingulata*, the stored carbon ranged from 32.05±0.72% (in the Kalapet coast of Puducherry during monsoon) to 35.15±0.66% (in the Hooghly estuary of West Bengal Sundarbans during premonsoon). In *C. obtusa*, the stored carbon in the flesh ranged from 34.93±0.86% (in the Kalapet coast of Puducherry during monsoon) to 39.14±0.91% (in the Hooghly of West Bengal Sundarbans estuary during premonsoon). In *S. cucullata*, the stored carbon in the fleshy part ranged from 34.99±0.87% (in the Kalapet coast of Puducherry during monsoon) to 40.15±0.92% (in the Hooghly estuary of West Bengal Sundarbans during premonsoon).

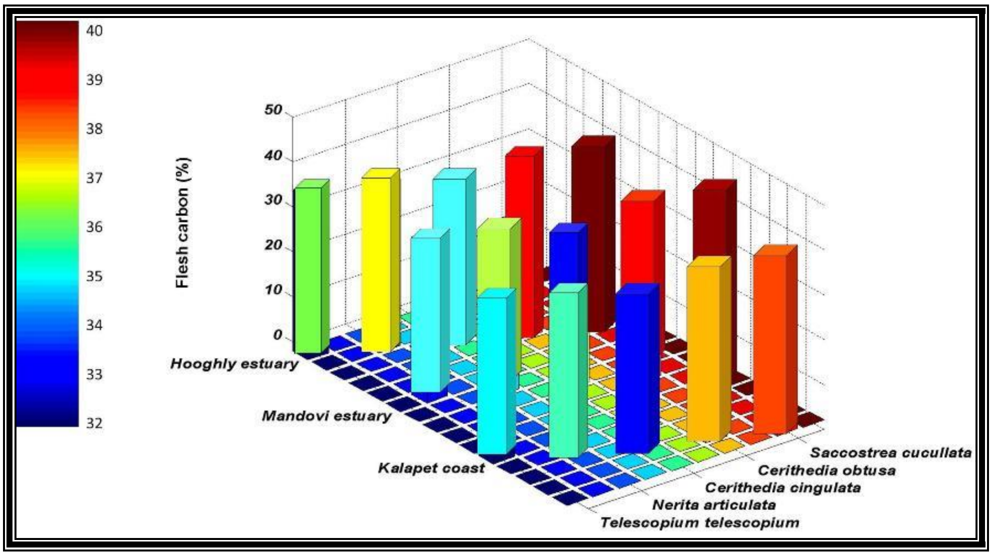

***Fig. 1:** Stored Carbon Percentage in Flesh of Dominant Molluscan Species in Premonsoon Season during 2014-15.*

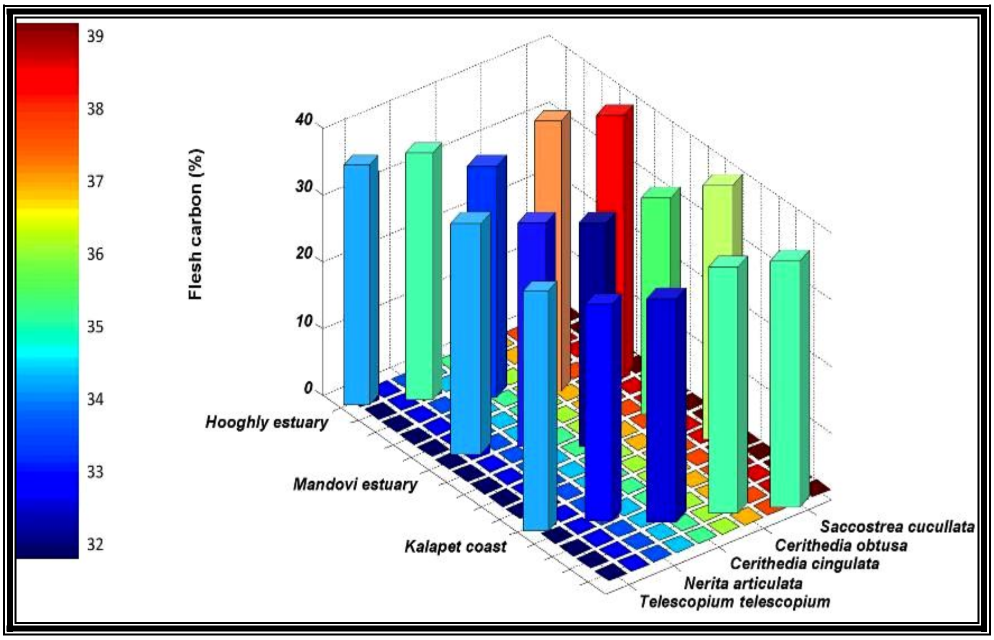

Fig. 2: *Stored Carbon Percentage in Flesh of Dominant Molluscan Species in Monsoon Season during 2014-15.*

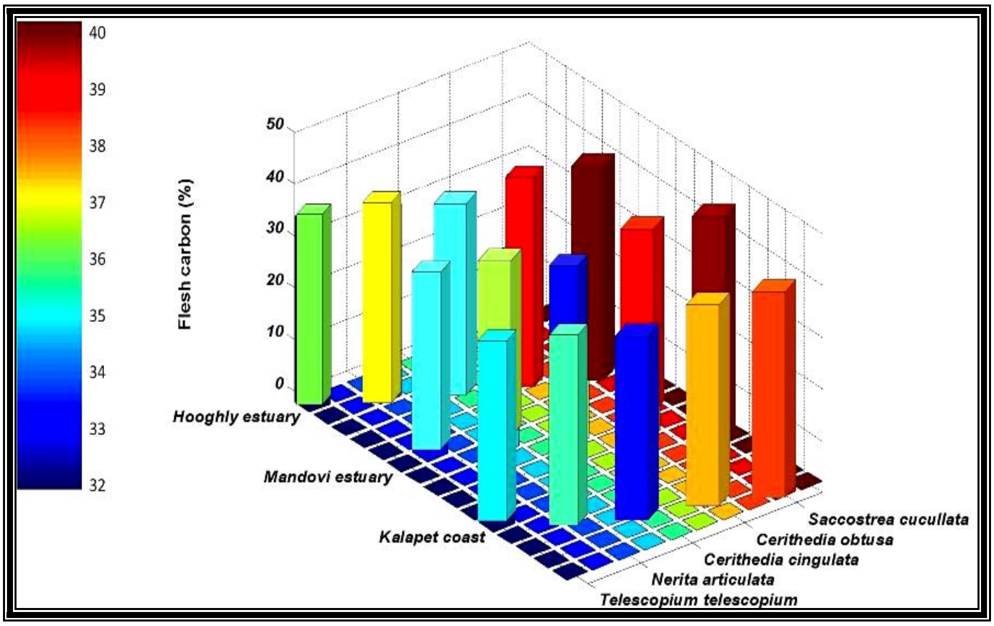

Fig. 3: *Stored Carbon Percentage in Flesh of Dominant Molluscan Species in Postmonsoon Season during 2014-15.*

The stored carbon percentages in the calcareous shells of the species inhabiting the selected stations are presented in Figures 4–6. In the shells of the selected molluscan species, the lowest and highest values were recorded in the Kalapet coast of Puducherry and Hooghly estuary of West Bengal Sundarbans respectively. In *T. telescopium*, the stored carbon ranged from 12.14±0.13% (during monsoon) to 12.98±0.11% (during premonsoon). In *N. articulata* shell, the stored carbon ranged from 12.16±0.15% (during monsoon) to 13.20±0.12% (during premonsoon). In *C. cingulata* shell, the stored carbon ranged from 12.00±0.12% (during monsoon) to 12.76±0.09% (during premonsoon). In the calcareous shell of *C. obtusa*, the stored carbon ranged from 13.00±0.16% (during monsoon) to 13.99±0.18% (during premonsoon). In *S.*

cucullata shell, the stored carbon ranged from 12.57±0.14% (during monsoon) to 14.23±0.19% (during premonsoon).

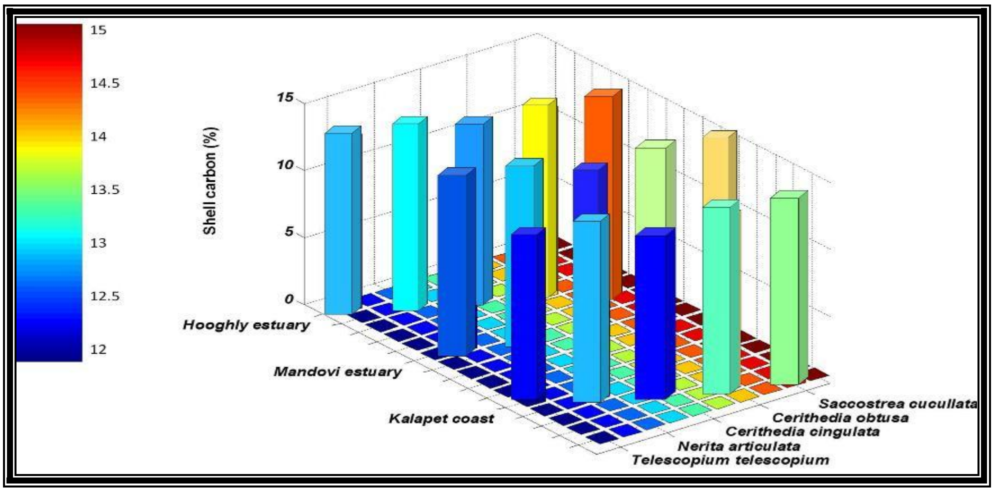

Fig. 4: *Stored Carbon Percentage in Shell of Dominant Molluscan Species in Premonsoon Season during 2014-15.*

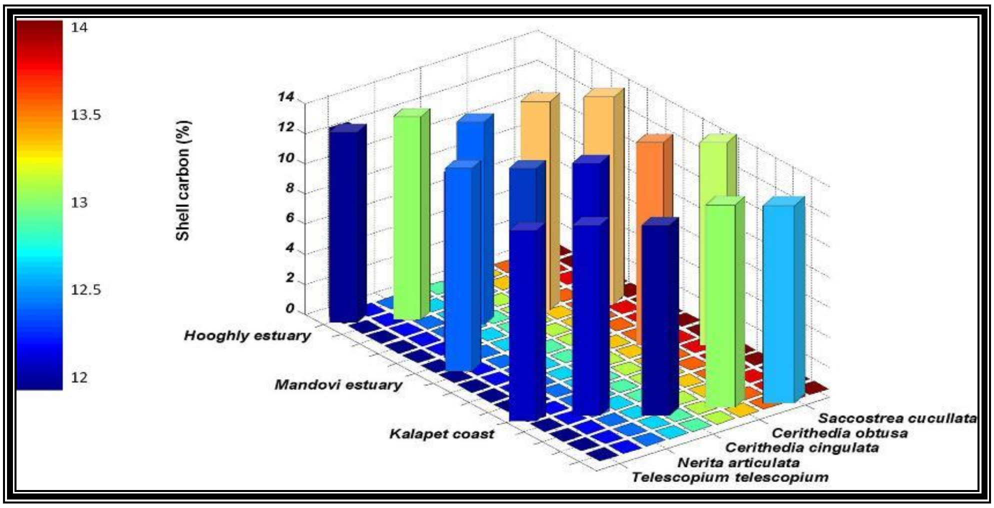

Fig. 5: *Stored Carbon Percentage in Shell of Dominant Molluscan Species in Monsoon Season during 2014-15.*

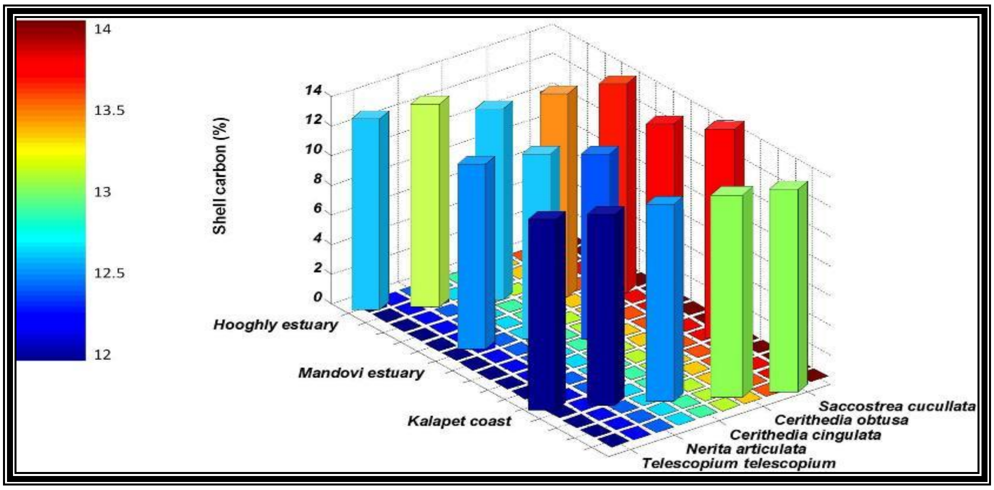

Fig. 6: *Stored Carbon Percentage in Shell of Dominant Molluscan Species in Postmonsoon Season during 2014-15.*

DISCUSSION

A comparative account of the stored carbon in the selected molluscan species shows that the flesh stores more carbon than the shell. The stored carbon in the flesh is in the order of *S. cucullata*>*C. obtusa*>*N. articulata*>*T. telescopium*>*C. cingulata*. A similar sequence is also observed in case of shell. Noteworthy is the seasonal variation of stored carbon in the selected species and the order is premonsoon>postmonsoon>monsoon. This seasonal variation may be attributed to the food preference and stored carbon in the diet of the molluscan species [2]. The molluscs under investigation depend on phytoplankton, macroalgae and detritus as their primary source of nutrition. The phytoplankton and macroalgae produce and store more carbon during premonsoon compared to the other two seasons [5]. This is because the premonsoon season in the tropics is characterized by maximum solar radiation and minimum suspended particulate matter in the aquatic system, which is congenial for maximizing the rate of photosynthesis leading to more production of organic carbon [6]. However, the seasonal variation of stored carbon is not significant in case of the shells of *N. articulata*, *C. cingulata* and *C. obtusa*. The spatial variation of stored carbon is pronounced for all species except in the shells of *C. cingulata* and *S. cucullata*.

The present study has immense importance as the carbon dioxide concentration over India is gradually increasing over a period of time. The mid-tropospheric carbon dioxide during 2002–2008 retrieved from Atmospheric InfraRed Sounder (AIRS) on board Advanced Microwave Sounding Unit (AMSU-A) was analyzed over the Indian subcontinent and surrounding oceans. Important features exhibited by the observations are the strong seasonal and latitudinal gradient modulated by strong monsoonal activity over the study region [1]. Further analysis suggests that atmospheric carbon dioxide concentration has increased linearly from 372 ppm in 2002 to 386 ppm in 2008 at the rate of 2.05 ppm/year during past 6 years over the study region with strong seasonal variation over the land and relatively weaker seasonal variability over the ocean [1]. West Bengal, a maritime state in the North-East part of India is no exception to this rule. The percentage of increase of carbon dioxide emission in West Bengal is 50.79% from 1980 to 2000 [7]. The increase in carbon dioxide in the air of coastal West Bengal is reflected through gradual increase of carbon in the floral community. Data on blue carbon are available in plenty from coastal West Bengal [2, 3, 8–12]. However, no research has yet been carried out on the stored carbon in the endemic faunal community. In the faunal community like shelled organisms, food and water are the major sources of carbon in their body. In case of gastropod, carbon in the body is acquired from four major sources, namely, atmospheric carbon dioxide, food, water and carbonate rocks. The habitat and nature of food greatly regulate the stored carbon in the gastropod shell and tissues. When these organisms consume and digest food (like phytoplankton, algal mat, mangrove leaves, detritus, etc., present in the coastal and estuarine regions), carbon is introduced to the hemolymph and passes along to the extrapallial fluid in the same way as atmospheric carbon dioxide. Then it mixes with the atmospheric carbon (taken during respiration) and finally shell carbonate is precipitated [13]. Carbon derived from detrital matter and urea (that originate from blue carbon through litter fall) breaks down into ammonia and carbon dioxide through urease reaction [14]. The resulting carbon dioxide is then introduced into the extrapallial fluid and ultimately incorporated into the cell carbonate. The stored carbon percentage in the marine and estuarine gastropod tissue is, therefore, greatly regulated by the nature of food they consume. According to some researchers, the stored carbon varies between 25 and 40% in gastropod that depends on plants or detrital matter [15]. Other scientists pointed out this range of stored carbon between 36 and 73% [16]. In the present study, the highest stored carbon in *C. obtusa* may be attributed to its dependence on algal mat deposited on the mangrove stems and pneumatophores. *N. articulata* depends on both seaweed and detritus for nutrition and therefore exhibits slightly lesser percentage of stored carbon in the tissue and shell. *T. telescopium* and *C. cingulata* are completely detritivorous in nature which may be the reason for their relatively low carbon percentage compared to *C. obtusa*. The results of the present study are almost similar to the findings of other researchers [17]. The present study confirms that the primary source of carbon in coastal and estuarine bivalves and gastropods is their diets, which mainly are phytoplankton, macroalgae or seaweeds in the coastal and estuarine regions or detritus on the intertidal mudflats. Thus the diet spectrum controls the carbon level in bivalves and gastropods in the coastal and estuarine environment. The results of the present study strongly advocate the inclusion of molluscs in the blue carbon vertical.

The present study generates few important messages that need to be addressed with long term vision:

1. Molluscs provide a wide array of ecosystem services including biodiversity, food for other members of higher trophic level, livelihood (through oyster and various bivalve culture), bioremediation of water and potential sink of carbon.
2. The molluscs are potential storehouse of carbon and the stored carbon is more in flesh compared to hard calcareous outermost shell.
3. The sources of carbon in molluscs are food, water and atmospheric carbon, but the food type regulates the percentage of stored carbon in the molluscan species.
4. Culture of edible molluscs may be an effective road map for reducing atmospheric carbon at local level.

REFERENCES

1. Nayak B, Zaman S, Devi SG, et al. Dominant gastropods of Indian Sundarbans: A major sink of carbon. *International Journal of Advances in Pharmacy, Biology and Chemistry*. 2014; 3(2): 282–89p.
2. Mitra A, Zaman S. *Carbon Sequestration by Coastal Floral Community*. The Energy and Resources Institute (TERI) TERI Press, India. 2014.
3. Mitra A, Zaman S. *Blue Carbon Reservoir of the Blue Planet*. *Springer*. 2015. ISBN 978-81-322-2106-7 (Springer DOI 10.1007/978-81-322-2107-4).
4. www.moef.nic.in/downloads/public-information/Chap-7-new.pdf
5. Mitra A, Zaman S, Pramanick P, et al. Stored carbon in dominant seaweeds of Indian Sundarbans. *Peternika Journal of Tropical Agricultural Science*. 2014; 37(2): 263–74p.
6. Mitra A. *Sensitivity of Mangrove Ecosystem to Changing Climate*. Springer. 2013; 62: 143–57p.
7. Ghoshal T, Bhattacharyya R. Carbon dioxide emissions, India, 1980-2000, ISRO Geosphere Biosphere Program (IGBP), National Carbon Project (NCP), Status Report-Soil and Vegetation-Atmosphere Fluxes. 20 Mar 2010. Indian Institute of Remote Sensing (NRSC), Indian Space Research Organisation, Dept. of Space, Govt. of India.
8. Banerjee K, Roy Chowdhury M, Sengupta K, et al. Influence of anthropogenic and natural factors on the mangrove soil of Indian Sundarbans wetland. *Archive of Environmental Science*. 2012; 6: 80–91p.
9. Raha A, Das S, Banerjee K, et al. Climate change impacts on Indian Sunderbans: A time series analysis (1924–2008). *Biodiversity and Conservation*. Springer. 2012. (DOI 10.1007/s10531-012-0260-z).
10. Sengupta K, Roy Chowdhury M, Bhattacharyya SB, et al. Spatial variation of stored carbon in *Avicennia alba* of Indian Sundarbans. *Discovery Nature*. 2013; 3(8): 19–24p.
11. Mitra, A, Sengupta K, Banerjee K. Pilot analysis of carbon sequestration by dominant mangrove species in Indian Sundarbans. *Proceedings of the All India Seminar on Global Warming – Corporate Responsibility*. Institute of Engineers (India). 11 and 12 Nov 2009; 92–102p.
12. Mitra A, Sengupta K, Banerjee K. Standing biomass and carbon storage of above-ground structures in dominant mangrove trees in the Sundarbans. *Forest Ecology and Management*. 2011; 261(7): 1325–35p.
13. Wilbur KM. Shell formation in molluscs, In: Florkin M, Scheer BT (Eds.). *Chemical Zoology, Mollusca*. Academic Press, New York. 1972; 7: 103–45p.
14. Scott LD. The influence of diet on the d13C of shell carbon in the pulmonate snail *Helix aspersa*. *Earth and Planetary Science Letters*. 2002; 195: 249–59p.

15. Goodfriend GA, Hood DG. Carbon isotope analysis of land snail shells: implications for carbon sources and radiocarbon dating. *Radiocarbon*. 1983; 25: 810–30p.
16. Romaniello L, Quarta G, Mastronuzzi G, et al. ^{14}C age anomalies in modern land snails shell carbonate from Southern Italy. *Quaternary Geochronolog*. 2008; 3: 68–75p.
17. Jurkiewicz-Karnakowska E. Some aspects of nitrogen, carbon and calcium accumulation in molluscs from the Zegrzyński reservoir ecosystem. *Polish Journal of Environmental Studies*. 2005; 14(2): 173–77p.

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