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ASPECTS OF SOME ELEMENTAL AND ANIONIC CONSTITUENTS OF *Egeria Radiata* LAMARCK FROM TWO CONTRASTING HABITATS IN THE CROSS RIVER, NIGERIA.

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ABSTRACT

Concentrations of nickel, calcium, iron, zinc, manganese, sulphate and carbonate, were determed in the soft tissue of the West African freshwater bivalve, Egeria radiata. Their relation to the two substratum types (sandy and silty) in which it occurs, and to some gross morphometric parameters, were assessed. There were no significant statistical differences in mean values of the morphometric attributes between both habitats, but the coefficients of variation showed higher variability of the parameters in bivalves from the silty substratum. Mean metals/anions levels showed no significant statistical differences between both habitats, and the coefficient of variation of their concentrations exhibited no clearly defined trend between the two habitats. The ecological significance of these results, and their nutritive and fishery relevance are discussed in light of increasing acceptability of the species as an alternative source of protein to humans, with concomitant intensified fishing pressure especially on the young bivalves.

INTRODUCTION

Recently, interest in the study of the West African fresh water bivalve, *Egeria radiata* Lamarck (*Galatea pparadoxa* Born) has led to the publication of many works (1, 2, 3, 4, 5 and 6) on various aspects of the biology of the species in the lower reaches of the Cross River system, Nigeria. More studies are envisaged as the nutritional and economic significance of the species have been appreciated by a wider segment of the society, its consumption no longer limited to the low income, rural and, urban slums populations (7).

Due to the wider acceptance of this species as a cheaper, and therefore, alternative source of protein to human, there has been increased exploitation pressure, with much of the fishing pressure on the young clams (8,9 and 10). In the Cross River system, the species is reported to occur more in medium grade sandy bottom (MdΦ - 0.07 to +0.89) than in coarse grade sand (MdΦ = 1.5 to - 0.06) with very few clams collected from silty deposits with high vegetable debris (10). The external surface of shells of the bivalve from silty substrates were darker than those from sandy beds (11).

This paper presents data on some morphometric measurements of samples of *E. radiata* from silty and sandy beds, as well as on some elements and anions in the soft tissue of bivalve. This was with a view to determining whether the reported difference in colouration between silty and sandy beds samples of the bivalve could be reflected in the measured attributes. All five metals analysed are essential to most animals. Carbonate is one of the inorganic ions which affect the standing stock of the bivalve by insuring its reproductive success (10). The ecological role of sulphate in regard to the clam is not known. It is of interest in this study because of its cathartic effect upon humans, hence our desire to know its levels in the bivalve. Descriptions of the Cross River system and its flood regime as it affects the river fisheries have been documented (12). The *Egeria* beds and its fishery have been reported (10 and 13).

MATERIALS AND METHODS

Twenty specimens of the bivalve were obtained from fishers at the fishing site, Itu (Latitude 5°13'N; Longitude 7°59'E).

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They were transported in a container with river water and sand to the laboratory to reduce transportation stress which could adversely affect the parameters to be determined. Sample preparation followed standard methods in APHA (14), Babukutty and Chacko (15). The elements were analysed by Atomic Absorption Spectrophotometer (UNICAM 919) while sulphate was analysed by the Barium Chloride-Gelatin reagent method, and carbonate by standard titrimetric method. Data were subjected to correlation and regression analyses with mean values tested for significance with students t-test. Coefficients of variation corrected for bias were computed to enable comparison of the variabilities of the measured parameters between the two habitats (16).

RESULTS AND DISCUSSION

A summary of the morphometric parameters, tissue weights and moisture content of the bivalves is presented (Table 1). There were no significant statistical differences in the mean values of all parameters between both habitats (t = 0.755, 1.044, 0.386, 0.626, 0.723, 0.58; df 8: $p>0.05$) for length, width, shell weight, wet tissue weight, dry tissue weight and moisture content respectively. The coefficients of variation of these parameters are illustrated in Fig. 1 which show that they exhibited higher variability in bivalves from the silty substratum. The length (L) range of the pooled samples was 6.7 -9.4 cm, with the corresponding weights (shell + tissue) of 45.33 - 129.5g. These values were positively correlated (r = 0.961, df 18: $p<0.01$), with 92.3% of the variation in weight (W) accounted for by changes in length. The regression equation for this relationship is:

$$W = 28.541 (L) - 144.31.$$

Similar analyses were made on other attributes and the regression relationships obtained with predictive value (Table II).

Mean concentrations and ranges of the metals and anions are presented (Table III). There were no significant differences between mean metal/anion levels in bivalves from the two

substrata (t = 1.421, 0.212; 0.049, 0.532, 0.800, 1.561, 1.675; df 9: $p>0.05$) for Ni, Ca, Fe, Zn, Mn, SO_4^{2-} and CO_3^{2-} respectively. The coefficients of variation of the concentrations of metals/anions (Fig. 2) indicated differences between bivalves from the two substrata, but without a consistent trend as in those of morphometric attributes and weights. Thus, variation in nickel (47.56%) and calcium (41.68%) concentrations in tissues from the sandy substratum were less than those from the silty substratum (50.52% and 47.58%) for nickel and calcium respectively). Iron (48.41%) and zinc (38.39%) from the sandy habitat varied more than that in the silty habitat (21.88% and 16.81% respectively). The differences in intra-habitat level of variation between nickel and calcium was higher in the sandy habitat than in the silty habitat. For iron and zinc the intra-habitat differences in the level of variation was higher in the sandy habitat than in the silty habitat, with a ratio of approximately 1:2. Variation in manganese levels was highest but did not differ in value between both habitats (52.1% either way). The anions, sulphate and carbonate also varied more in sandy habitat (27.85% and 29.42% respectively) than in the silty habitat (14.45% and 15.0% respectively). Intra-habitat variation levels of the two anions were low, but higher in the sandy habitat.

Statistical analysis relating morphometric parameters to metals/anions concentrations are presented (Tables IV and V). These show very low and non-significant correlation coefficients and regression parameters. Manganese exhibited consistent negative correlation with shell weight, moisture content, and wet and dry tissue weights. Sulphate and carbonate also correlated negatively with moisture content and wet and dry tissue weights. Iron correlated negatively with dry tissue weight only. Further analysis of the interrelationship between manganese, iron and nickel showed an insignificant negative relationship between nickel and manganese, while a medium positive relationship was obtained between manganese and iron (r = 0.5233, df 18: $p<0.1$), with 27.4% of the variation in manganese accounted for by variation in iron concentrations, with the following functional relationship:

$$Mn = 0.00298 + 0.2402\ (Fe)$$

Of the five metals, zinc exhibited the least variability in both habitats (38.39% and 16.81% in the sandy and silty habitats respectively), while manganese varied the most (52.1% in either habitat). Lack of significant statistical variations of metals concentrations with bivalve weights in this study agrees with some reports in the literature (17) for *Tagelus dombeii* and *Semelle solida;* and (15) for *Villorita cyprinoides* var. *Cochinensis).* Temporal variations of metals concentrations in bivalve tissues are believed to cause lack of significant variations of metals levels with bivalve weights (18). Seasonal fluctuations in tissue mass of the organism is cited as a major temporal factor, and has been reported to occur in *E. radiata* of the Cross River system (19). Significant correlation and lack of it in metals levels and weights of bivalves were attributed to the processes controlling metal bioavailability to the organism (20). According to them copper and zinc concentrations which correlated significantly with weights of *Macoma balthica* are controlled by biological processes, whereas cadmium which showed no correlation with weights of the species is controlled by its levels in the environment.

A significant fraction of trace metals in the aquatic system is reported to be associated with the bottom sediments where it is partitioned among various fractions of the soil, such as the exchangeable fraction, the fraction bound to organic matter, carbonate, and iron and manganese oxide (21 and 22). Exchangeable metal fractions and metals bound to carbonate are said to be loosely bound and therefore in equilibrium with their concentrations in the water column. They are thus liable to be released more frequently onto the overlying waters (23). A major portion of zinc is partitioned into the exchangeable and carbonated fractions, and hence readily available. This explains its low variability in both habitats.

The absence of significant differences in numerical values of morphometric attributes and metals/anions in bivalves from the

two contrasting habitats indicates that the observed external shell surface colour difference is superficial. The dark colour of specimens from the silty habitat is possibly imparted by humic substances from the abundant decayed and decaying organic matter in the sediment. Sandy beds have little or no organic debris in them and bivalves inhabiting them have lighter colour. The reported low standing stock of the clams in silty substrata may be due to limitations posed by the fine particulate nature of the soil of the habitat vis-a-vis nutrient dynamics or to the possibility of smothering by resuspended particulate during periods of agitations. This seems to be in accordance with the higher variability of the morphometric attributes and some metals in bivalves from the silty habitat. Furthermore, the higher variability of nickel and calcium in the silty substratum derives from temporal fluctuations in their inputs into the river along with high sediment loads during spates.

The small- scale intra-habitat differences in the coefficients of variation of sulphate and carbonate concentrations in both habitats suggest a relatively stable rate of release and uptake. However, the inter-habitat differences in variability were large and shows bivalves in the silty habitat as obtaining a relatively more stable input. Adsorption of these ions onto exchangeable fractions of the sediment could ensure relative stability in the medium and hence a steady release, in contrast to the more porous sandy habitat. The stability of the carbonate ion in particular and its steady bioavailability would therefore guarantee its role in enhancing reproductive success of the bivalve.

The low and non- significant correlations between some metals and the measured body parameters suggests that their availability to the bivalve is not controlled by biological processes, while the availability of iron and manganese which correlated positively and significantly is controlled by biological processes (20). The negative correlations between sulphate, carbonate, manganese, and iron with some morphometric parameters of the bivalve and significant from the standpoint of the nutritive relevance of the bivalve. These indicate increases in concentrations of these anions and elements in young bivalves, with reductions in their concentrations in large and older individuals.

Absence of size selectivity in *Egeria* fishing was reported (13). Increased exploitation pressure on the bivalve in recent years, with much of the fishing pressure on the young clams 4.0 cm in length, corresponding to 1 year old individuals was reported (8, 9 and 10). Probable reasons for the non-selective capture of young clams are:

* high financial returns to the fishers.
* non-selective consumption with regard to size.
* possible low standing stock of the adult clams.

Danger in Consuming Young Clams

Our findings indicate that consumers of this species may be inadvertently getting increased dietary manganese, iron, sulphate and carbonate from the young clams. This would be encouraging since the essentiality of iron and manganese in human nutrition has been established (24). However, the case of the anions, particularly sulphate, is of concern. Sulphate is reported to produce a cathartic effect upon humans when present in excessive amounts (25). Although the concentrations of sulphate in bivalve tissue reported in this study are low (Fig.2) and well within recommended maximum limit of 250mg/l (26), the phenomenon of biomagnification could make regular consumption of young clams potentially dangerous.

Need for Conservation

The continued capture of young clams and their acceptance by consumers is a major threat to the Cross River clam fishery, especially since the developmental biology of the species is yet to be studied. Increased fishing pressure on the young clam is unhealthy because the species has a low turnover ratio of less than 1.0, with a limited distribution (10). This practice he observed, can lead to a rapid extinction of the stock.

Long-term benefits gradually derived from an enduring

resource should be allowed to transcend the short-term gains derived from a stochastically exploited resource. Although Etim (4) reports the existence of cohorts of hermaphroditic *E. radiata* in the Cross River system, with adaptive significance, the reported 3.5% abundance does not guarantee a quick recovery (if at all) in the event of a collapse of the fishery, assuming the hermaphrodites are spared by chance. Allowing young clams to grow to adult sizes before capture would help obviate the potential danger from accumulating dangerous levels of sulphate by prolonged consumption of young clams. Moreover, Hardin's "tragedy of the commons", recently played out in the collapse of the Peruvian anchovy *(Eugraulis encrasicholus* fishery) (28) through overfishing (29) should be avoided through rational management programmes (presently lacking) aimed at curbing the non-selective capture of young clams which should be left to mature and contribute to stock recruitment into the fishery.

Table I. Mean Values (Ranges in Parentheses) of Length and Weights of Morphometric Attributes of *Egeria radiata* From Sandy and Silty Substrate, with the Pooled Data

Habitat	n	Length (cm)	Width (cm)	Shell weight (g)	Wet Tissue weight (g)	Dry Tissue weight (g)	Moisture content (g)
Sandy	10	7.6 (6.8-8.5)	4.37 (3.8-5.0)	58.88 (35.75-80.62)	16.07 (9.58-23.4)	4.32 (2.49-6.25)	11.75 (7.09-17.3)
Silty	10	8.05 (6.7-9.4)	4.12 (3.5-5.1)	64.19 (26.28-102.3)	18.9 (7.44-28.55)	5.31 (1.71-8.33)	13.59 (5.73-2-.22)
Pooled	20	7.83 (6.7-9.4)	4.39 (3.5-5.1)	61.58 (26.28-102.39)	17.48 (7.44-28.55)	4.82 (1.71-8.33)	12.67 (5.73-20.22)

Table II. Functional Equations Relating Length (Lt), Width (Wd) and Shell Weight (Sw) to Moisture Content (Mc), Wet Weight (Ww) and Dry Weight (Dw) of *Egeria radiata*.

Dependent variable (y)	Independent Variable (x)	Linear regression (y- a + bx	Correlation coefficient (r)	Variation accounted for (r^2)
Moisture content (MC)	Length (Lt:cm)	MC = 5.156Lt - 27.676	0.978	0.956
Moisture content (MC)	Width (wd:cm)	Mc = 9.641Wd - 29.671	0.901	0.812
Moisture content (MC)	Shell Weight (SW:g)	MC = 0.216SW - 0.592	0.924	0.854
Wet weight (WW)	Shell Weight (SW:g)	WW = 0.309SW - 1.512	0.924	0.916
Dry weight (DW)	Shell Weight (SW:g)	Dw = 0.093SW - 0.919	0.916	01838

Table III. Mean Concentrations (mg g-l) of Metals and Anions (Ranges in Parentheses) in the Tissue of *Egeria radiata* From Sandy and Silty Substrate, with the Pooled Data.

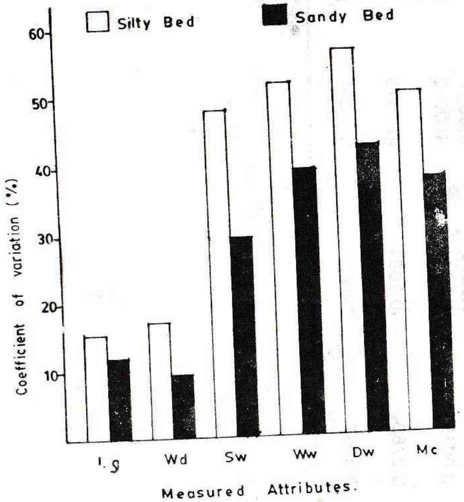
Habitat	n	Ni	Ca	Fe	Zn	Mn	SO_4^{2}	Co_3^{2}
Sandy	10	0.022 (0.011-0.034)	0.295 (0.098-0.44)	0.099 (0.028-0.152)	0.057 (0.019-0.08)	0.028 (0.013-0.049)	0.318 (0.22-0.454)	0.294 (0.206-0.428)
Silty	10	0.033 (0.011-0.054)	0.311 (0.168-0.572)	0.1 (0.08-0.124)	0.062 (0.055-0.081)	0.018 (0.011-0.027)	0.382 (0.32-0.458)	0.361 (0.322-0.43)
Pooled	20	0.027 (0.011-0.054)	0.303 (0.098-0.572)	0.099 (0.024-0.152)	0.059 (0.019-0.081)	0.023 (0.011-0.049)	0.349 (0.22-0.458)	0.328 (0.206-0.43)

Table Iv. Correlation and Regression Parameters Relating Weight (SW) and Moisture Content (MC) of *Egeria radiata* to Metal/anion Concentrations of its Tissue.

Statistical Parameter	Related Variables						
	SW & Ni	SW & Ca	SW & Fe	SW & Zn	SW & Mn	SW & SO_4^{-2}	SW & CO_4^{-2}
Intercept (a)	0.0167	0.2525	0.0979	0.0385	0.0296	0.3334	0.3154
Slope (b)	0.00017	0.00082	0.00003	0.00034	-0.00011	0.00027	0.00019
Correlation coefficient (r)	0.2806	0.1499	0.0204	0.499	0.2146	0.0812	0.0606
Variation accounted for (r^2)	0.0787	0.0225	0.00042	0.249	0.0461	0.0066	0.0037
	MC & Ni	MC & Ca	MC & Fe	MC & Zn	MC & Mn	MC & SO_4^{-2}	MC & CO_4^{-2}
Intercept (a)	0.0174	0.265	0.0976	0.049	0.0293	0.3647	0.3452
Slope (b)	0.00079	0.00299	0.00017	0.00083	-0.00051	-0.00118	-0.0014
Correlation coefficient (r)	0.2977	0.1276	0.0265	0.2815	-0.2391	-0.0835	-0.0991
Variation accounted for (r^2)	0.0886	0.0163	0.0163	0.0793	0.0571	0.00696	0.00981

Table V. Correlation and Regression Parameters Relating Wet Weight (WW) and Dry Weight (DW) of *Egeria radiata* to Metal/Anion Concentrations in Claim Tissue.

Statistical Parameter	Related Variables						
	WW & Ni	WW & Ca	WW & Fe	WW & Zn	WW & Mn	WW & SO_4^{2-}	WW & CO_3^{-2}
Intercept (a)	0.0174	0.2659	0.0983	0.0494	0.0288	0.3634	0.3436
Slope (b)	0.00057	0.00022	0.00008	0.00057	-0.00034	0.00077	-0.00091
Correlation coefficient (r)	0.3098	0.1293	0.0181	0.2807	-0.2295	0.0788	-0.936
Variation accounted for (r^2)	0.0959	0.0167	0.00033	0.0788	0.0527	0.00621	0.0088
	MC & Ni	MC & Ca	MC & Fe	MC & Zn	MC & Mn	MC & SO_4^{-2}	MC & CO_4^{-2}
Intercept (a)	0.0176	0.2687	0.0999	0.0505	0.0276	0.3603	0.3399
Slope (b)	0.00204	0.0071	0.00002	0.0019	-0.001	-0.0022	-0.0026
Correlation coefficient (r)	0.3356	0.1323	-0.0014	0.2769	-0.2061	-0.0676	-0.0803
Variation accounted for (r^2)	0.1126	0.0175	0.000002	0.0767	0.0425	0.0046	0.0065



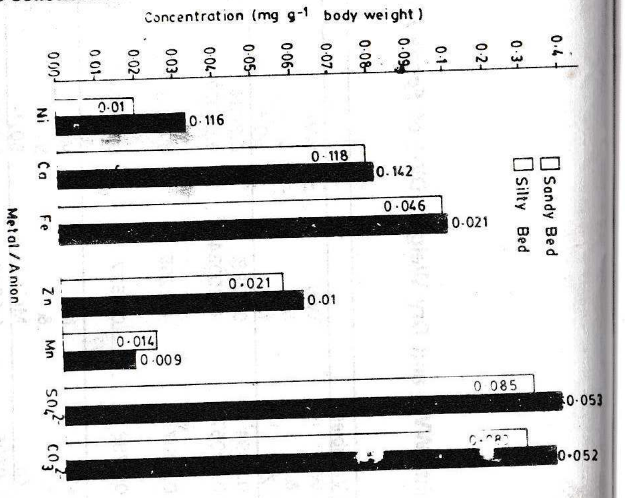


Fig. 1. Values of morphometric altributes of *Egeria radiata* from sandy and silty habitats. Lg = length, Wd = width; Sw = shell weight; Ww = weight tissue weight; Dw = dry tissue weight; Mc = moisture content.

Fig. 2. Mean concentrations of metals/anions (±SD in figures)in*Egeria radiata* tissues from sandy and silty habitats.

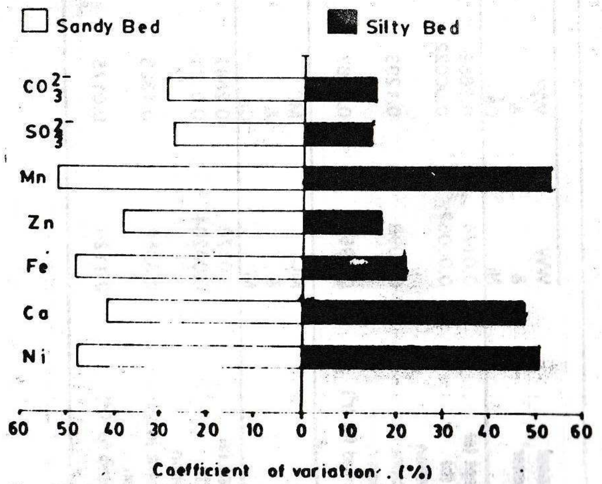


Fig. 3. Coefficients of variation of metal/anion concentrations in *Egeria radiata* tissue from sandy and silty habitats.

REFERENCES

1. Odiete, W. O. Walter and chloride ion regulation in the freshwater mussel, *Egeria radiata* L. (Bivalvia, Tellinacea, Donacidae). Nig. J. Nat. Sci. 1: 93-97. 1979.
2. Odiete, W. O. The cruciform muscle complex in *Egeria radiata* L. (Bivalvia, Tellinacea. Donacidae). BASTERIA. 45: 57 -63. 1981.
3. Etim, L. Annual variation in proximate composition and condition of *Egeria radiata* (Bivalvia: Donacidae) from the Cross River in Nigeria. Nigerian J. Tech. Res. 2: 95 -98. 1991.
4. Etim, L. Determination of reproduction cycle in a population of *Egeria radiata* (Lam 1804) (Bivalvia: Donacidae) using condition index and histological examination of gonads. Annis. Limnol. 32: 105 -113. 1996.
5. Etim, L. and Enyenihi, U. K. Annual cycle, condition and flood season spawning in *Galatea paradoxa* (Born 1777) from the Cross River, Nigeria. Trop. Freshwater Biol. 2: 234 -248. 1991.
6. Etim, L. & Taege, M. Comparison of condition indices and their seasonal variation in the freshwater clam, *Egeria radiata* (Lamarck) Tellinacea:) Donacidae) from the Cross River, Nigeria. *Aguacult. Fish. Manage* 24: 603 - 612. 1993.
7. Ifon, E. T. and Umoh, I. B. Biochemical and nutritional evaluation of *Egeria radiata* (clam), a delicacy of some riverine peasant populations in Nigeria. Food Chemistry 24: 21 -27. 1987.

8. King, R. P., Egwali, E. C. and Nkanta, N. A. Population dynamics of freshwater clam *Galatea paradoxa* (Donacidae) in the Cross River, Nigeria. Fishbyta. 9: 34 -36. 1992.
9. Etim, L. and Brey, T. Growth, productivity and significance for fishery of the bivalve *Egeria radiata* (Donacidae) in the Cross River, Nigeria. Arch. Fish. Mar. Res. 42: 63 -75. 1994.
10. Moses, B. S. Growth, biomass, mortality, production and potential yield of the West African clam, *Egeria radiata* (Lamarck) (Lamellibranchia, Donacidae) in the Cross River system, Nigeria. Hydrobiologia. 196: 1 -15. 1990.
11. Udoidiong, O. M. and Apan, P. M. Toxicity of cadmium, lead and lindane to *Egeria radiata* Lamarck (Lamellibranchia, Donacidae). Rev. hydrobiol. Trop. 24: 111-117. 1991.
12. Moses, B. S. The influence of flood regime of fish catch and fish communities of the Cross River floodplain ecosystem, Nigeria. Environmental Biology of Fishes. 18:51-65.1987.
13. King, R. P. and Udoidiong, O. M. Perspectives in the development and conservation of freshwater fisheries resources of the Crose River, Nigeria. Trans. Nig. Soc. Biol. Conserv. 2: 7 -16. 1991.
14. APHA Standard methods for the examination of water and waste water including bottom sediments and sludges, 15th edn. American Water Works Association, APHA- AWWA-WPCF, PP. 148 - 157. 1980.
15. Babukutty, Y. and Chacko, J. Trace metals in an estuarine bivalve from the Southwest coast of India. AMBIO. 21: 292 - 296. 1992.
16. Sokal, R. R. and Rohlf, F. J. Biometry, second edition, W. H. Freeman and Company, New York. P. 589. 1981.

17. De-Gregori, I., Delgado, D., Pinochet, H., Gras, N., Munoz, L., Bruhn, C. and Navarrete, G. Cadmium, lead, copper and mercury levels in fresh and canned bivalve mussels *Tagelus dombeii* (Navajuela) and Semelle solida (Almeja) from the Chilean coast. Sci. Total Environ. 148: 1 -10. 1994.
18. Luoma, S. N., Cain, D. and Johansson, C. Temporal fluctuations of silver, copper and zinc in the bivalve *Macoma balthica* at five stations in south San Francisco Bay. Hydrobiologia. 129: 109 - 120. 1995.
19. Etim, L., Akpan, E. R. and Muller, P. Temporal trends in heavy metals concentrations in the clam *Egeria radiata* (Bivalvia: Tellinacea: Donacidae) from the Cross River, Nigeria. Rev. hydrobiol. Trop. 24: 327 -333. 1991.
20. Bordin, G., McCourt, J. A. and Rodriguez, A. Trace metals in the marine bivale *Macoma balthica* in the Westerschelde estuary (The Netherlands). Part 1: Analysis of total copper, cadmium, zinc and iron concentrations - locational and seasonal variations, Sci. Total Environ 127: 255 - 280. 1992.
21. Tessier, A., Capbell, P. G. C. and Bisson, M. Particulate trace metal speciation in sediments and relationships with grain size: implication for geochemical exploration. J. Geochem. Exploration. 16: 77-104. 1982.
22. Babukutty, Y. and Chacko, J. Chemical partitioning and bioavailability of lead and nickel in an estuarine system. Environ. Toxicol. Chem. 14: 427 - 434. 1995.
23. Das, S. and Kaviraj, A. Seasonal variation in the partitioning and bioavailability of copper and zinc in four pisciculture ponds of an industrial town. Proc. Zool. Soc. Calcutta. 45 (Suppl. A): 177 - 183. 1992.
24. Kirchgessner, M., Reichimayr-Lais, A. and Maier, R. Ni retention and concentrations of Fe and Mn in tissues resulting from different Ni supply. In: Trace elements in man and animals. TEMA 5. Commonwealth Agricultural Bureaux, Uk. PP. 147 - 151. 1985.

25. Sawyer, C. N. and McCarty, P. L. Chemistry for environmental engineering, third edition. McGraw-Hill Kogakusha Ltd., Tokyo. PP. 532. 1978.

26. Culp, G. L. and Culp, R. L. New concepts in water purification. Van Nostrand Reinhold Company, New York, PP. 2- 25. 1974.

27. Hardin, G. The tragedy of the commons. Science. 162: 1243 - 1248. 1968.

28. Paulik, G. J. Anchovies, birds and fishermen in the Peru current. In: Resource management and environmental uncertainty - lessons from coastal upwelling upwelling fisheries. John Wiley & Sons, New York PP. 334 - 356. 1981.

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