International Journal of Fisheries and Aquatic Sciences 4(2): 21-29, 2015
ISSN: 2049-8411; e-ISSN: 2049-842X

Submitted: May 19, 2014 Accepted: June 18, 2014 Published: November 20, 2015

Research Article

Ash Content of Benthic Polychaetes from An Estuarine Creek in the Niger Delta: Implications for Energetics

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Abstract: The Azuabie Creek in the upper Bonny Estuary of the Niger Delta, Nigeria receives waste inputs from domestic and industrial sources. The ash content of polychaetuos annelids was examined as part of a larger study on the impacts of urban and industrial contamination on the creek. Sediment samples were collected and analyzed from ten sampling stations for a period of one year (April 2006 to March 2007). There were spatial and temporal variations in the ash content of polychaetes of the study area with most species showing significant differences. The values of *Streblospio* sp dominated at stations 5, 6 and 7 where the other polychaetes were poorly represented. The mean ash content of *Boccardia* sp, *Nereis* spp, *Nephtys hystricis* and *Nephtys hombergi* was highest at station 1 while *Polydorella* sp was highest at station 7; these showed significant differences between sites and months of sampling as well as interactions ($p<0.001$). The highest mean value of *Glycera convoluta* was recorded at Station 1 with significant spatial variation ($p<0.001$), but no significant difference between months. *Notomastus latriceous* and *Notomastus tenius* had their highest mean ash contents in Stations 1 and 2 with significant differences between sites ($p<0.001$), but no significant temporal variation. The highest mean value of *Capitella capitata* was recorded in Station 7 followed by Station 5; showing significant spatial and temporal variations as well as interaction. There were significant spatial and temporal differences as well as interactions in the ash content of *Onuphis* sp and *Fabricia filamentosa*. *Parkinsianariwo* and *Nothria* also had significant spatial differences ($p<0.001$) and interaction ($p<0.01$) but no significant differences between months. *Hediste* had significant difference in sampling stations but not sampling months. However, *Sigambra* had significant differences both in location and period with no significant interactions. The ash content of polychaetes in the upper Bonny Estuary tended to mirror the relative abundance of the species. It is therefore concluded that ash-free dry weight of the polychaetes will be a good predictor of biomass and energy content within the system.

Keywords: Ash content, Azuabie creek, biomass, energetics, Niger Delta, polychaete

INTRODUCTION

In shallow water systems, such as coastal lagoons, the benthic compartment plays a crucial role in determining the functioning of the system. Controlling the main ecological processes and changes in its structure could affect the whole system (Snelgrove *et al*., 1997; Weslawski *et al*., 2004; Tenore *et al*., 2006). The introduction of industrial and urban sewage to the marine environment cause changes to the structure of benthic communities. The analysis of these changes constitutes an important tool in interpreting and evaluating the effects of contaminants in a particular ecosystem both in space and time (Heip, 1992). Marine benthic communities are considered to exhibit the greatest potential for integrating conditions in a site (Bilyard, 1987). The ability of the benthic communities to reveal spatial and temporal changes make them the target for most environmental monitoring programmes developed either to detect signs of habitat change or to assess the effectiveness of restoration plans (Warwick, 1993; Jan *et al*., 1994).

While Biomass and abundance of benthic communities are selected among the biological variables highly recommended for monitoring programmes by the GESAMP (1980), biomass is usually considered to be a more objective measure of the real living substance and considered a major goal in benthic ecological research (Palmerini and Bianchi, 1994; Hatcher, 1997). Biomass data always offer a comparatively average dispersion of the analysis performed on the basis of progressively decreasing levels of taxonomic resolution. Biomass is generally considered as a better biotic attribute than abundance for routine measurement in benthic monitoring studies (Clark and Warwick, 1994; Pagola-Carte *et al*., 2002). Neuhoff, (1979) measured the influence of the ash fraction on the biochemical parameters in a population of *Nereis succinea* population and observed a shifting of the energy maximum depending on whether values

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are based on dry weight or ash free dry weight. Moslen and Daka (2014) describe the attributes of subtidal benthic populations of the Azuabie creek in the upper Bonny Estuary, Niger Delta, Nigeria in relation to density. We report here the spatial and temporal variations in of the ash content of benthic polychaetes from the Azuabie Creek of the upper Bonny Estuary.

MATERIALS AND METHODS

Study sites: Ten sampling stations were located along the Azuabie Creek, to cover of land-based sources of contaminant inputs into the creek as well as presumably uncontaminated locations (Fig. 1). The sampling stations and their geographical coordinates of these stations are as follows: Stations 1 (4°48'08.871"N, 7°04'15.763") and 2 (4°48'19.958"N, 7°03'46.932"E) were relatively away from any visible anthropogenic influence but stations 3 (4°48'28.591"N, 7°03'29.218"E) 4 (4°48'12.462"N, 7°03'16.906"E) and 5 (4°48'18.675"N, 7°03'25.946"E) were located along the creeklet that receives industrial effluents from Trans-Amadi Industrial drains in addition to a waste dump site that is close to station 3. Stations 6

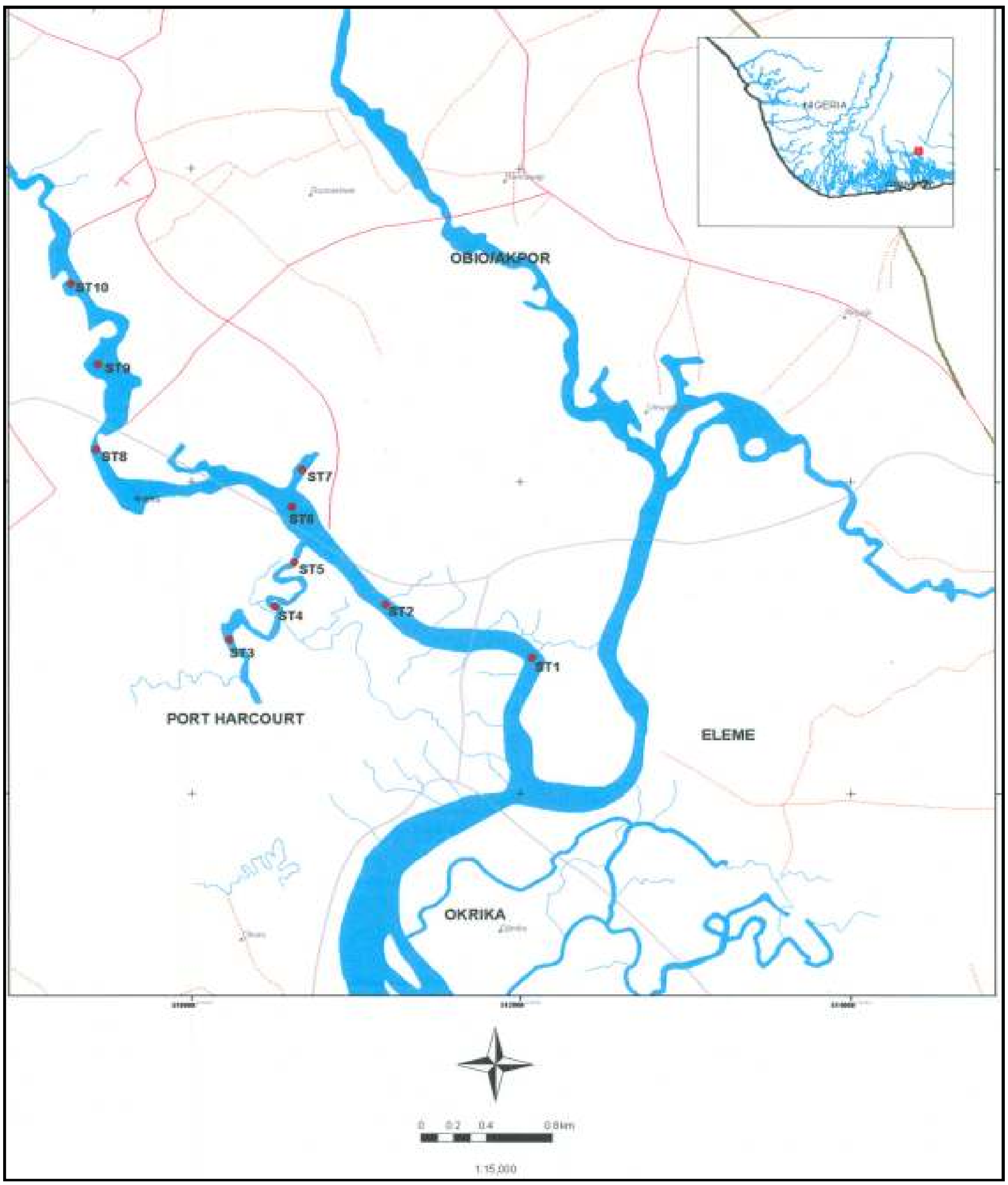

Fig. 1: Azuabie Creek showing locations of sampling stations. Inset–The Niger Delta showing location of the Azuabie Creek

(4°48'40.150"N, 7°03'28.370"E) and 7 (4°48'48.411"N, 7°03'30.411"E) were close to a domestic waste dumpsite and a pier latrine. Station 8 (4°48'52.041"N, 7°02'49.661"E) was close to a major abattoir and some industries while stations 9 (4°49'09.796"N, 7°02'50.446"E) and 10 (4°49'26.711"N, 7°02'44.237") were also close to domestic waste inputs upstream of the creek.

Sample collection and analysis: Sediment samples were collected monthly with an Ekman grab (15 cm by 15 cm) at each of the stations for a period of one year from April 2006 to March 2007. The benthos/sediment samples were collected randomly from five different spots (five replicates) per station for biological analysis. Additional two grabs were also collected for physicochemical analysis of the sediment. This was taken to the laboratory, dried at room temperature for the analysis of sediment characteristics. For the analysis of biological samples, the sediment samples were washed through a 1 mm sieve to obtain the macrofauna. The material retained by the sieve were placed in a container and preserved with 5% formalin brackish water mixture, stained in Rose Bengal to facilitate sorting in the laboratory.

Laboratory analyses of infauna were carried out shortly after field sampling. Aliquots of the sample were transferred on to a white surgical tray with water for sorting. The detrital sediment samples were then sorted using a pair of forceps and a hand lens. The macro-infanuna found were collected and preserved in small vials containing 5% formlin water mixture. The contents were later identified to the lowest possible taxonomic level using appropriate keys (Day *et al*., 1981) and others for example (Fauchald, 1977). Only the heads of organisms were counted, since the individuals were sometimes fragmented.

The ash content of polychaetes was determined using twenty-full sized (standard) individuals which provided the multipliers with which the ash content of the populations of each species was projected from the faunal density. The standard animals were first rinsed in two runs of re-distilled water to eliminate foreign bodies, dust and preservatives. In absorbent paper towelling, they were blot-dried for about 3 to 5 min. The dry weight of the samples were obtained by drying in an oven (Gallenkamp) at 60°C for 24 h and after, cooling at room temperature in a desiccator and re-weighing on a weighing balance (AE ADAM AFP-360L model). For the ash content, the dried samples were placed in a muffle furnace at 550°C for 4 h and then reweighed after cooling in a desiccator at room temperature.

Data analysis: Two-way ANOVA with replication was used for statistical analysis to determine significant differences in the ash content of each species with station and season as the fixed factors. Where ANOVA result showed a significant difference, Bonferoni test were performed for mean separation. MINITAB (R14) was used to carry out the statistical analysis.

RESULTS AND DISCUSSION

There were spatial and temporal variations in the ash content of polychaetes of the study area (Fig. 2 to 6), with most species showing significant differences (Table 1). The values of *Streblospio* sp dominated at stations 5, 6 and 7 (Fig. 2A), the while other annelids were poorly represented. The mean ash content of *Boccardia* sp was highest (0.45 g/m^2) in the month of December while across sites, it was found to be highest (0.41 g/m^2) at station 1 (Fig. 2B). *Polydorella* sp was

Table 1: Summary of Two-Way ANOVA for ash content of polychaetes

	F-values		
Species	Month	Station	Month x station
Streblospio sp	8.70***	21.02***	3.90***
Boccardia sp	30.85***	42.13***	13.36***
Polydorella sp	10.47***	4.69***	2.81***
Polydora sp	2.87**	8.50***	2.38***
Nereis spp	4.76***	39.36***	1.72***
Nephtys hystricis	6.07***	41.08***	2.36***
Nephtys hombergi	3.79***	26.09***	1.74***
Glycera convoluta	0.83 ns	11.67***	0.89 ns
Notomastus latriceous	1.21 ns	11.56***	1.36*
Notomastus tenius	1.67 ns	18.03***	1.51**
Capitalla capitata	7.84***	15.22***	2.48***
Nothria sp	0.43 ns	9.86***	0.48 ns
Onuphis sp	1.93*	12.77***	1.46**
Perkinsiana riwo	1.30 ns	7.04***	1.50**
Fabricia filamentosa	2.34**	5.19***	2.11***
Hediste sp	0.57 ns	6.70***	0.68 ns
Sigambra bassi	2.13*	3.41***	0.93 ns

*** = p≤0.001; ** = p≤0.01; * = p≤0.05; ns = not significant

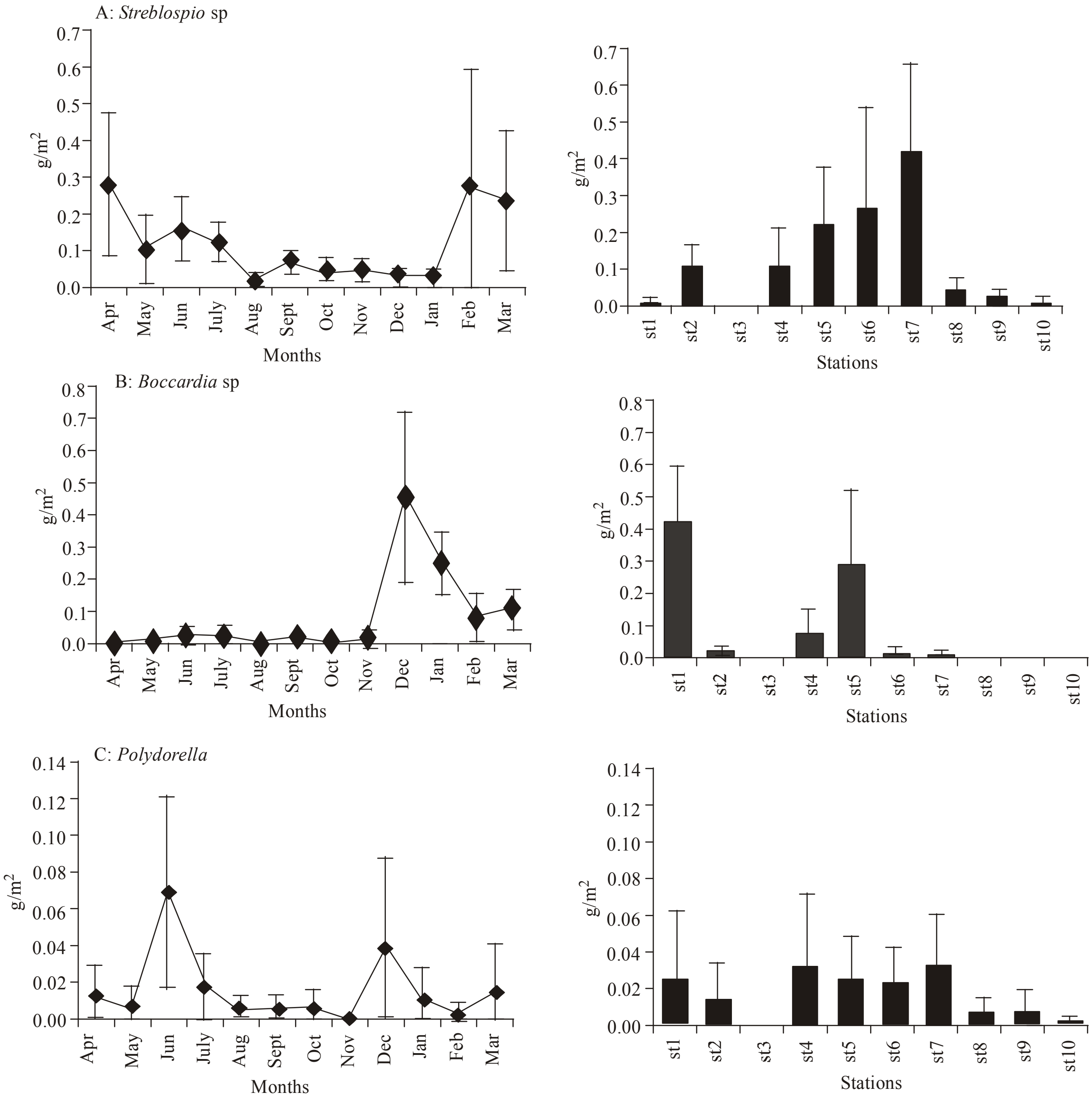

Fig. 2: Mean (±SEM) ash content (g/m^2) of *Streblospio* sp, *Boccardia* sp *and Polydorella* sp

highest at station 7 during the rainy season month of June (Fig 2C); there were significant differences between stations and months as well as a significant interaction (p<0.001, Table 1).

The mean ash content of *Nereis* spp (Fig. 3A), *Nephtys hystricis* (Fig. 3B) and *Nephtys hombergi* (Fig. 3C) were higher at Stations 1 and 2 and generally reduced from Station 4 to Station 10. There were significant differences between sites and months of sampling as well as interactions (p<0.001, Table 1). The highest mean value of *Glycera convoluta* was recorded at Station 1 (Fig. 3D) with significant spatial variation, but no significant difference between months (Table 1).

Notomastus latriceous (Fig. 4A) and *Notomastus tenius* (Fig. 4B) had their highest mean ash contents in Stations 1 and 2 with significant differences between sites (p<0.001), but no significant temporal variation. The highest mean value of *Capitella capitata* was recorded in Station 7 followed by Station 5 (Fig. 4C); showing significant spatial and temporal variations as well as interaction.

There were significant spatial and temporal differences as well as interactions in the ash content of *Onuphis* sp (Fig. 5A) and *Fabricia filamentosa* (Fig. 5B). *Parkinsianariwo* (Fig. 5C) and *Nothria* sp (Fig. 5D) also had significant spatial differences (p<0.001) and interaction (p<0.01) but no significant differences between months (Table 1). *Hediste* (Fig. 6A) and *Sigambra bassi* (Fig. 6B) had very poor mass of ash

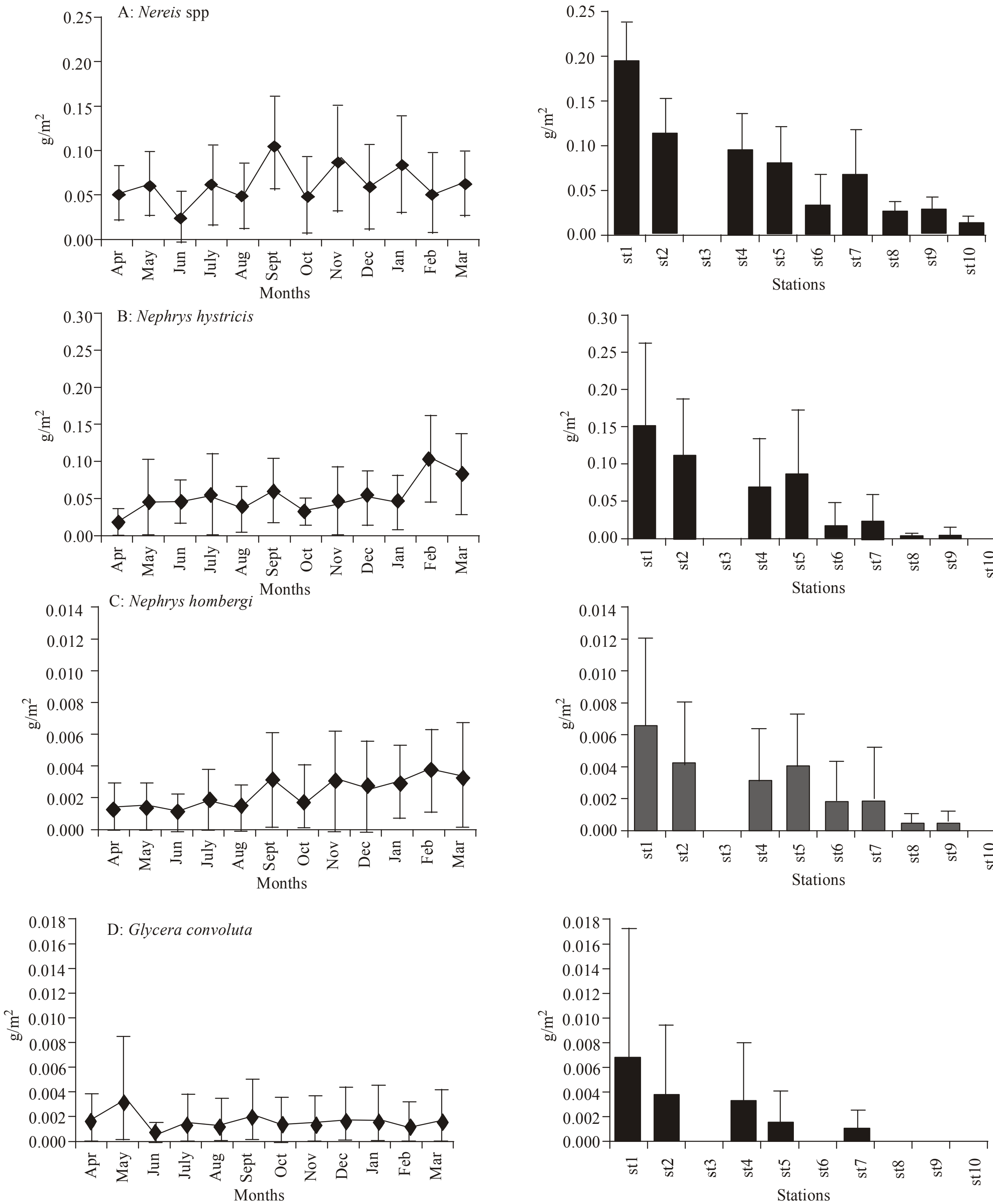

Fig. 3: Mean (±SEM) ash content (g/m^2) of *Nereis* spp, *Nephryshystricis, Nephtyshombergi* and *Glycera convoluta*

and were recorded only in four out of the 10 sampling stations over the study period. *Hediste* had significant difference in sampling stations but not sampling months. However, *Sigambra* had significant differences both in location and period with no significant interactions.

Ash content was found to be generally higher during the dry season (November to March) than the rainy season (May to October) and was also directly proportional to the numerical abundance of polychaetes (Moslen and Daka, 2014). The ash content of *Nereis* spp was higher a stations 1 and 2 downstream of the

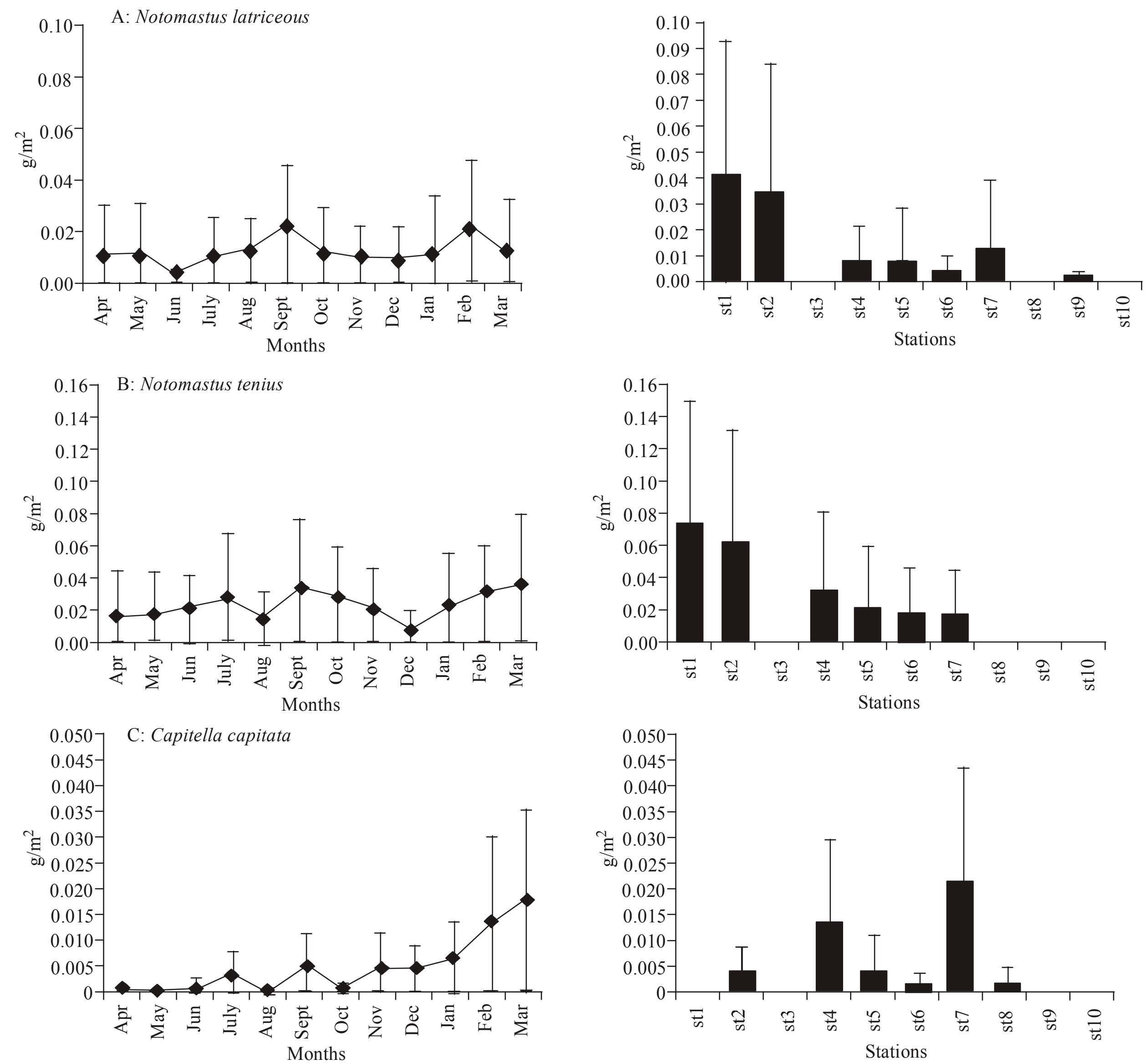

Fig. 4: Mean (±SEM) ash content (g/m^2) of *Notomastus latriceous, Notomastus tenius* and *Capitella capitata*

creek, but that of *Boccardia* sp was higher in station 1 especially, during the dry season. At stations 5, 6 and 7 midstream of the creek, the ash content of the spionids (*Streblospio*, *Polydora* and *Polydorella*) were predominant. It is important to add that the presence of S*treblospio*, a polychaete found predominantly at stations 5, 6 and 7 had the highest mass of ash in those stations indicating that they had a higher ash content than the minority taxa due to their high numerical abundance despite their small size (Cortelezzi *et al*., 2007). Generally, the numerical dominance of spionids at stations 1, 5, 6 and 7 also showed a corresponding dominance in their ash content. In Nueces Bay, Texas, Manino and Montagna (1997) found strong associations between physicochemical variables such as salinity, sediment composition and nutrient concentrations and broad macrobenthic metrics, including biomass, abundance and diversity. Dauer *et al*. (1993) noted that contaminated sediments pose a multitude of stress on benthic communities that collectively lead to reduced biomass and species richness and to dominance by shallow-dwelling opportunistic taxa (Rakocinski *et al*., 2000).

Station 3 receives effluents mainly from Rivers Vegetable Oil Company (RIVOC) through one of the drains that leads to the industrial layout and is also close to peer latrines and domestic waste dumpsites. Peterson *et al*. (1996) observed that the introduction to marine environments of organic contaminants such as petroleum can promote the abundance of some tolerant species or result in the extinction of more sensitive species due to high toxicity of some compounds.

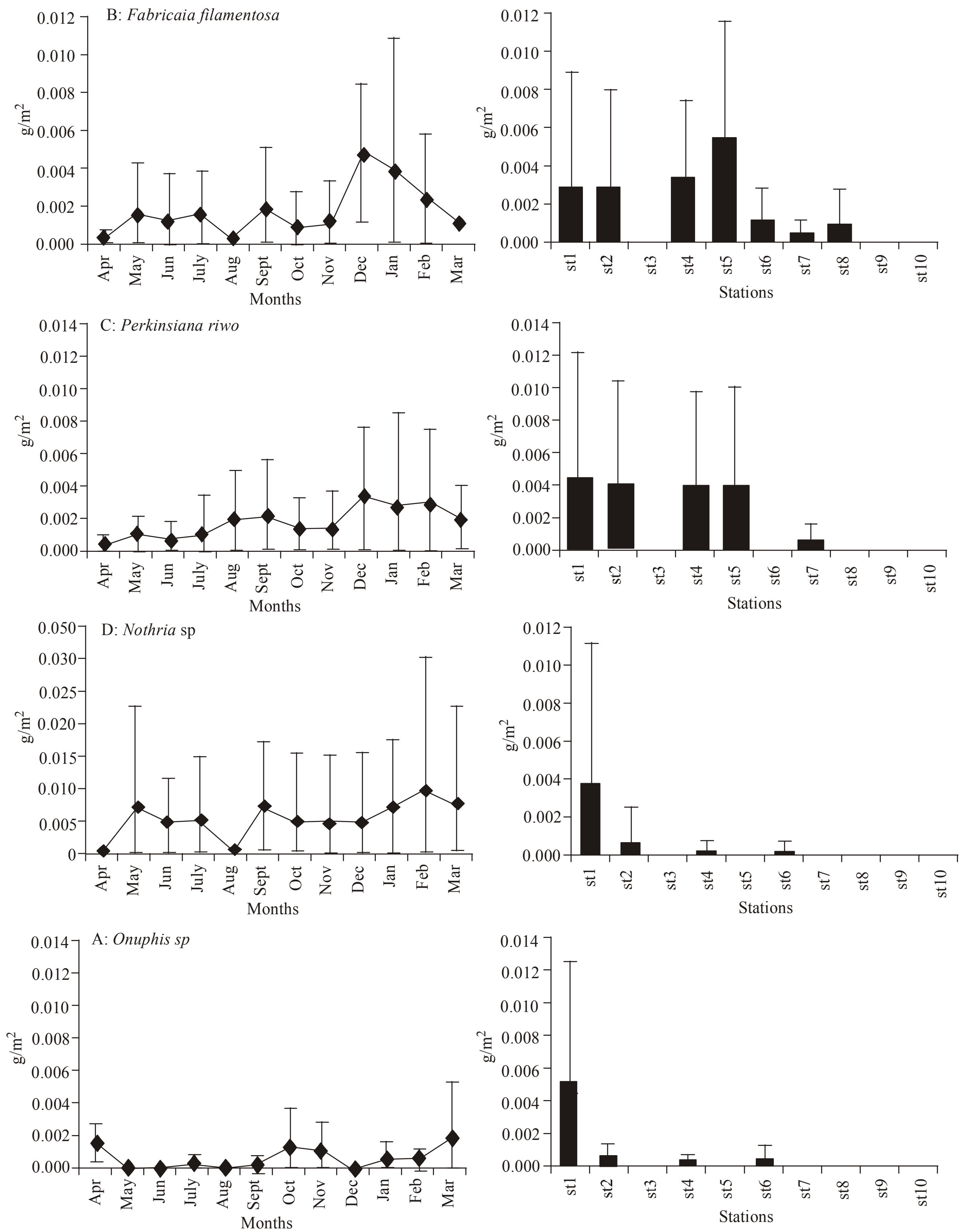

Fig. 5: Mean (±SEM) ash content (g/m^2) of *Onuphis sp., Fabricia filamentosa, Perkinsiana riwo* and *Nothria* sp

Station 3 was completely azoic (defaunate) all through the study period. The concentration of pollutants such as THC, TOC and Heavy metals were quite high at this station but a combination of these pollutants with anoxic conditions could be responsible for the azoic condition found at this site. This is reflected in the low DO and high BOD levels recorded at this site (Ekeh, 2010). It is therefore, pertinent to state that sediment quality criteria based solely on concentration of contaminants should be used with caution because

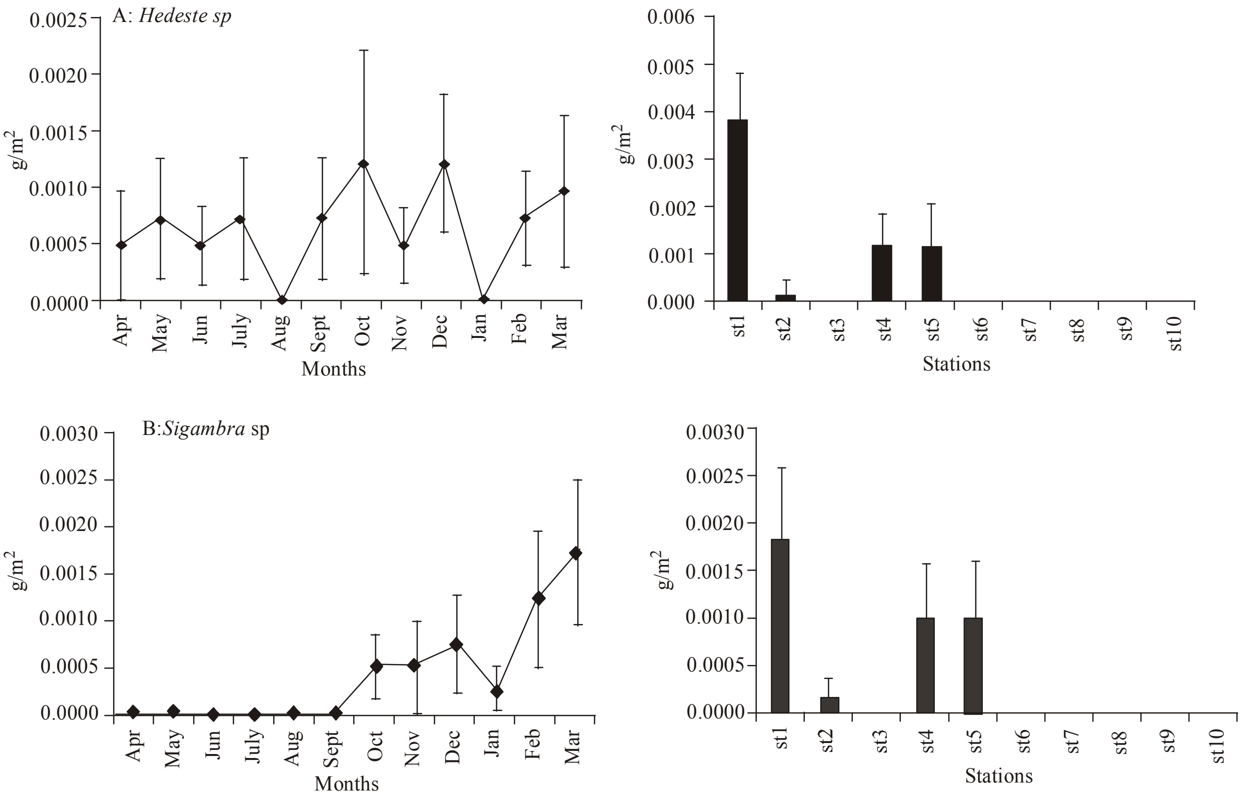

Fig. 6: Mean (±SEM) ash content (g/m^2) of *Hedeste* sp and *Sigambra* sp

hypoxia has been shown to be more critical for the establishment of a normal benthic fauna in Oslo harbour (Trannum *et al*., 2004). From the lack of effects of contaminated harbour sediments on recolonization of fauna, Trannum *et al*. (2004) concluded that it is the low concentration of oxygen in the bottom water, rather than contaminants, that was the main responsible agent for the poor benthic fauna in Oslo harbour area, though, a combination of high contaminants and hypoxia caused an extra load on the fauna. Bottom type salinity and turbidity front are also major physical variables that affect benthic community structures (Giberto *et al*., 2004).

Fauchald and Jumars (1979) studied the diet of worms and reported that there are various ways of grouping species into functional units (e.g., by degree of opportunism, by reproductive behaviour). Discrimination according to feeding patterns however seems appropriate as a basis for analysis of energy transfers within an ecosystem.

CONCLUSION

The ash content of polychaetes in the upper Bonny Estuary tended to mirror the relative abundance of the species. It is therefore concluded that ash-free dry weight of the polychaetes will be a good predictor of biomass and energy content within the system.

ACKNOWLEDGMENT

We acknowledge the assistance of Dr G. C. Akani in the identification of some of the invertebrates and the Department of Chemical Engineering, RSUST, Port Harcourt for use of the muffle furnace.

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