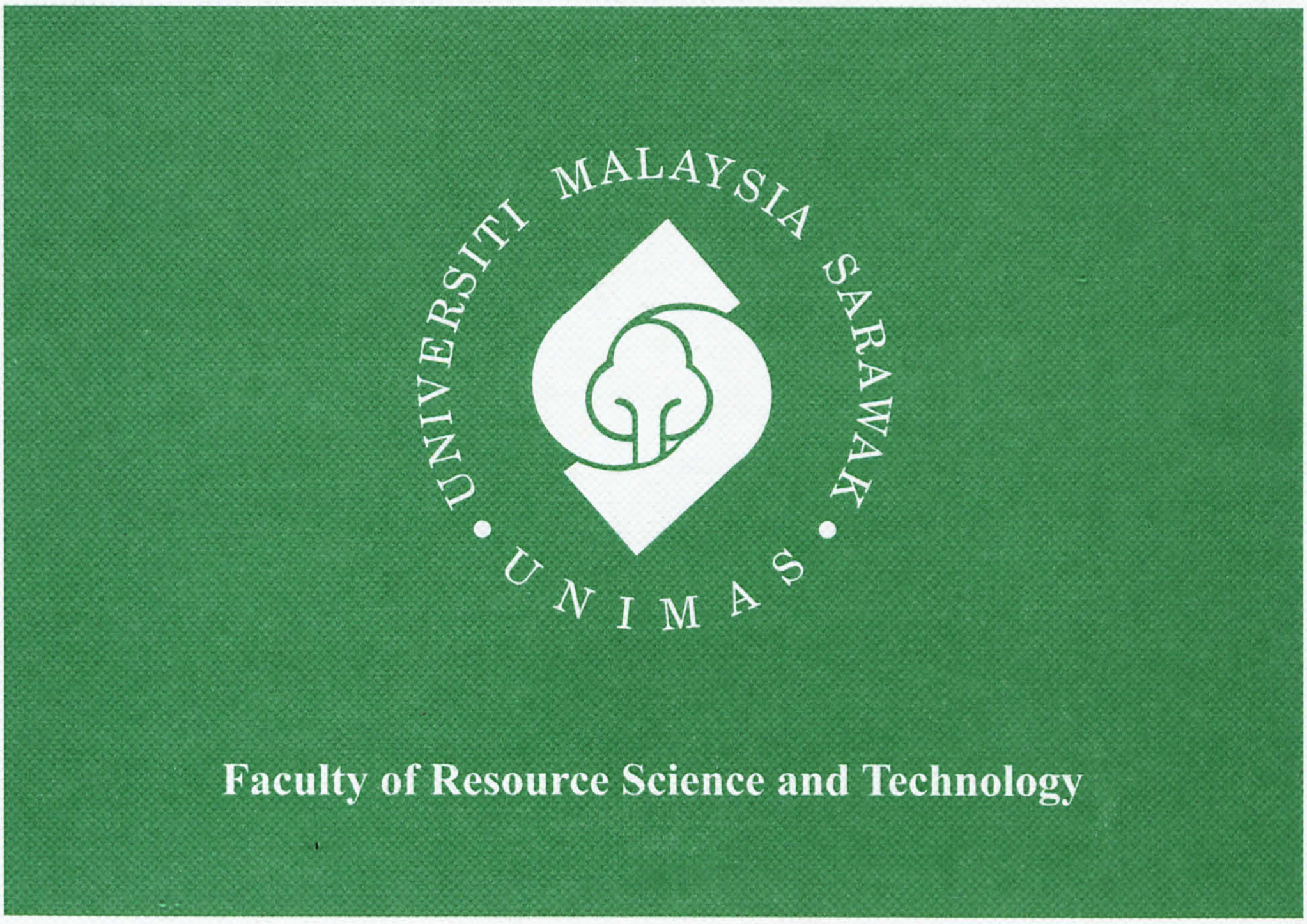

COMMUNITY ECOLOGY OF FREE-LIVING MARINE NEMOTODES IN SARAWAK COASTAL WATERS

Chen Cheng Ann

Master of Science
2010

Pusat Khidmat Maklumat Akademik
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COMMUNITY ECOLOGY OF FREE-LIVING MARINE NEMATODES IN SARAWAK COASTAL WATERS

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A thesis submitted in fulfillment of the requirement for the degree of

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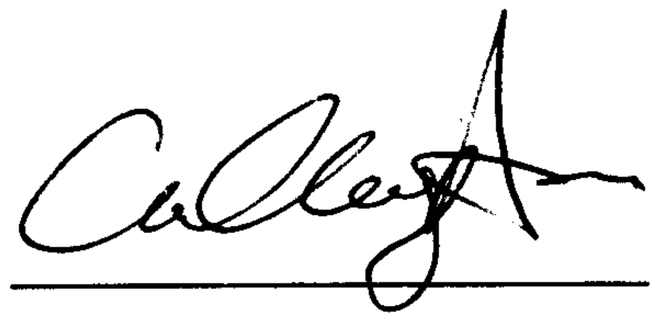
DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries, which have been dully acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Sarawak or other institutions.



CHEN CHENG ANN

MAY 2010

DEDICATION

This thesis is dedicated to my respected supervisor, Professor Dr Haji Shabdin Mohd Long. My beloved family members: father (Chen Soo Nan), mother (Wong Toh Teck), my elder brother (Chen Cheng Horng) and special mate of mine (Soo Chen Lin) for being so supportive and always be there for me. Last but not least, to my lab-mate (Norliana Mohd Rosli) for all the supports and efforts.

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ABSTRACT

This is the pioneer study focused on the community study of marine nematode (until the species level) in Sarawak. The surveys on the marine nematode were carried out at 20 sites along the Sarawak coastal waters. A total of 87 species of marine nematode had been recorded along the Sarawak coastal waters. Miri Beach had the highest abundance and species number of marine nematodes followed by Sematan River. Results showed that the abundance of the marine nematode in the coastal study was significantly different (p-value < 0.05) and correlated to the four parameters: pH, DO, sand and silt (correlation = 0.311). In the horizontal study of the nematode in Teluk Awar (Kuching), particle size fractions showed no significant difference between sites (p-value > 0.05) but significantly different between stations (p-value < 0.05; R-statistic = 0.349). The result of the present study showed that the marine nematode assemblages in Teluk Awar were mostly dominated by the functional feeding group (FFG) of 1B and 2B type except for station B2, A9 and B9. Vertical study of nematode in Teluk Awar showed that at the depth of 0-5 cm, the recorded species were *Daptonema hirstum* (70.48%) and *Daptonema tenuispiculum* (20.26%) with the average similarity of 10.81. The nematode species was not found below 15 cm sediment depth. Different pattern of nematode abundance is recorded in the sandy and muddy site for the seasonal study. The seasonal study showed that the marine nematode community structure not only affected by the particle size fractions (sandy /muddy) but also the seasonal rainfall.

EKOLOGI KOMUNITI NEMATODA MARIN YANG HIDUP BEBAS DI PERSISIRAN PANTAI SARAWAK

ABSTRAK

Kajian ini merupakan kajian perintis yang dijalankan di Sarawak mengenai komuniti nematod marin (sehingga peringkat spesies). Kajian di sepanjang perairan pantai Sarawak merangkumi 20 kawasan. Sebanyak 87 spesies nematod marin telah direkodkan di sepanjang perairan pantai Sarawak. Pantai Miri direkodkan mempunyai bilangan individu dan jumlah spesies yang paling tinggi dan diikuti oleh Sungai Sematan. Keputusan terhadap bilangan individu nematod marin dalam kajian perairan pantai menunjukkan perbezaan bererti berasaskan kepada kiraan nilai-p (0.001) dan berhubung kait dengan empat parameter iaitu pH, oksigen terlarut, pasir dan tanah liat (nilai perkaitan = 0.311). Dalam kajian taburan mendatar terhadap nematod di Teluk Awar (Kuching), kepelbagaian saiz butiran pasir menunjukkan tiada perbezaan bererti di antara kawasan (nilai-p = 0.899) tetapi menunjukkan ada perbezaan bererti di antara stesen (nilai-p = 0.025; R-statistik = 0.349). Keputusan dalam penyelidikan ini menunjukkan nematod marin di Teluk Awar didominasi oleh kumpulan pemakanan berfungsi (FFG) jenis 1B dan 2B kecuali pada stesen B2, A9 dan B9. Kajian taburan menegak terhadap nematod di Teluk Awar menunjukkan spesies Daptonema hirsutum *(70.48%) dan* Daptonema tenuispiculum *(20.26%) boleh dijumpai pada kedalaman 0-5 cm dengan nilai purata persamaan 10.81. Spesies nematod tidak ditemui selepas kedalaman sedimen 15 cm. Bentuk yang berbeza direkodkan bagi jumlah bilangan nematod di kawasan berpasir dan berlumpur dalam kajian bermusim. Kajian bermusim menunjukkan struktur komuniti nematod marin bukan sahaja dipengaruhi oleh kepelbagaian saiz butiran pasir (berpasir/ berlumpur) tetapi juga oleh taburan hujan.*

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Nematodes are categorized as one of the most diverse taxa in the meiobenthos groups. They comprise of numerous and widely distributed groups in the world of fauna. They can be found worldwide in the sea, fresh waters and also the soil. Nematodes can be found with different characteristics such as parasitic or free-living. Nematodes are well-known based on their diverse taxa in every habitat supporting life and also the roles in aquatic ecosystem (Platt and Warwick, 1983). A total of 11, 000 – 20, 000 of nematode species had been described so far and about 4,000 - 5,000 species are free-living (Giere, 2009). It is believed that the diversity of the nematode is yet waiting for further discovery.

Free-living marine nematodes play an important role in the benthic processes. According to Chinnadurai and Fernando (2007), the great nematode abundance adaptator to a wide range habitat and diverse morphology suggest that the nematodes play an important role in benthic ecosystem backing up the studies carried out by Gal'tsova (1971) and Coull (1988) where nematodes play a significant role in the trophic chain and break down of organic substances in the benthic community. More researchers realized the importance on the character of the distribution of meiobenthos which is dominated by the free-living marine nematodes and harpacticoids in the littoral zone and its seasonal variations (Sasekumar, 1994; Somerfield *et al.*, 1998; Shabdin and Othman, 2005; Shabdin, 2006a, 2006b). It may be assumed that the organisms of the meiobenthos are uniformly distributed in the entire littoral zone or, contrarily, that their distribution is patchy (Gal'tsova and Platonova, 1985). The adaptations of nematodes to life in a zone periodically exposed to low and high tides, having an unstable

regime with respect to temperature, salinity, variability of food, and other factors are one of the fields of interest that had been studied nowadays.

Free-living nematodes constitute the major part of the meiobenthos. They have a vertical and horizontal distribution pattern on a global scale which dominant in marine sediments from the coastal areas to the deep ocean and at all latitudes (Heip *et al.*, 1985; Platt and Warwick, 1988; Da Rocha *et al.*, 2006). Ecological studies of the marine nematodes (Platt, 1977; Warwick and Price, 1979; Heip *et al.*, 1985; Yodnarasri *et al.*, 2008; Adão *et al.*, 2009; Hourtson *et al.*, 2009) had shown the importance of the marine nematodes in marine environment.

Most of the studies on free-living marine nematodes had been carried out in temperate countries on the horizontal studies (Warwick, 1971; Blome, 1983; Tietjen, 1976; Gheskiere *et al.*, 2004), ecological studies (Ott and Schiemer, 1973; Platt, 1977; Forster, 1997; Vermeeren *et al.*, 2004) and also the environmental pollution impact study (Gee *et al.*, 1985; Riemann *et al.*, 1990; Neilson *et al.*, 1996; Pinto and Bemvenuti, 2006; Mahmoudi *et al.*, 2005; 2006; Moreno *et al.*, 2008). The studies mentioned above just a small portion of examples to be shared which will not much discuss in here.

Limited research had been done in the tropical countries especially the Southeast Asia (SEA) countries. The historical study related to the marine nematode was scarce in Malaysia. Sarawak is the largest of Malaysia's thirteen states holding the world's oldest and second largest tropical rainforest after the Amazon and Sarawak is a marvel of biodiversity (Sarawak Government, 2008). Most of the studies that had been carried out were related to the parasitic nematodes. Ecological data on horizontal, vertical, seasona distribution of the marine

nematode until the species level still limited in tropical country such as Malaysia compared to the other regions. The seasonal variation of the tropic is not similar as the temperate countries. In this case, the distribution and abundance of the nematodes might possibly dissimilar with the temperate countries. In order to further the research on marine nematodes, it is important to carry out the research to identify the species and also the distribution pattern of free-living nematodes in the coastal water of the tropical country such as Sarawak.

In Sarawak, the studies related to free-living marine and estuarine nematodes only began in 1999 (Shabdin, 2006a). Preliminary studies that had been conducted so far only covered the density of higher meiobenthos taxa including nematodes (Tengku Balkis, 2000; Farizah, 2001; Sarinah, 2004; Imelda, 2005; Shabdin, 2006b). Instead of the high expectation in the richness of the biodiversity in the tropical country like Malaysia, the studies of nematodes in Sarawak are still at the infancy stage. Only handful of studies related to the free-living marine nematodes were carried out (Shabdin, 1998; 2006a; 2006b; Shabdin and Othman, 1999, 2005, 2008; Chen and Shabdin, 2008; 2009).

Further research on marine nematodes can only be carried out after understanding the influence of the physico-chemical parameter of the environement (i.e. temperature, dissolved oxygen, salinity, grain size, redox potentials discontinuity, turbidity, rainfall) and also the biological parameters (cholorophyll *a* and total organic matter) in the sediment on the community structure. The present study focuses on the ecology of free-living nematode species in Sarawak which potentially can be used for future pollution monitoring and also as an alternative diet in hatchery industry.

The objectives of this study are:

I. to determine the community structure of free-living nematodes and its relationship with environmental parameters of Sarawak coastal water.

II. to study the horizontal distribution of free-living marine nematodes from high tide to subtidal stations.

III. to determine the vertical profiling of free-living marine nematodes at the intertidal zone.

IV. to study the seasonal variations of free-living nematode species in different habitat types (i.e. muddy and sandy area).

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1.2 Literature review

1.2.1 Historical study of nematode

Several descriptions such as meiobenthos and meiofauna have been used in categorizing the free-living marine nematodes. However, the definition of each term is crucial to be understood prior to any further approaches to prevent confusion or misleading. The term of the meiobenthos was coined in 1942 by Molly F. Mare to define the benthic metazoans that can be distinguished from macrobenthos by their small sizes. The term of "meio" is defining the organisms that pass through the 500μm but retain on the 44μm mesh width sieves (Giere 2009). Meiofauna is having a synonymous definition to the meiobenthos but it includes all the motile aquatic animals that can be found in fresh and marine water. The term of the meiobenthos is chosen to be used in this study due to the closer approach in explaining the ecology of the organism in benthic ecosystem. Meiobenthos occur in all types of sediment and occupy a wide variety of habitats which help in the production of detrital organic matter and recycling of nutrients that enriching the coastal waters to support the marine benthic products (Chinadurai and Fernando, 2007). Ecology studies of the meiobenthos (i.e Warwick and Gee, 1984; Alongi, 1987a; Chinnadurai and Fernando, 2007) had engrossed the attention of the researcher globally.

The study of free-living marine nematodes began in the 1860's. It covered mainly the species composition, anatomy, and morphology of different species. The ecology, biology and zoogeography of free-living marine nematodes had received less attention than their systematic and morphology (Gal'tsova, 1971). In the 1920's and 1930's, almost no work was done on the quantitative distribution of meiobenthos especially on marine nematodes. The

lacking of literature review on taxonomic and technology in maintaining the nematode species in the laboratory had been quite scattered during the earlier studies, making determination of nematodes a frightening affair and putting the ecologist to an embarrassing position of studying the animals that they could not even name (Heip *et al.*, 1985).

According to Gal'tsova and Platonova (1985), a large number of works on individual groups of meiobenthos had been published (Nematoda, Copepoda, Ostracada) yet a number of others are still not fully understood. However, the study of small benthic organisms (meiobenthos) which the size of does not exceed 0.1 to 3.0 mm had increased significantly since last few decades. Starting from there, free-living marine nematodes had attracted the interest of researchers to participate in the related field especially in the ecological and taxonomic study. In the past decades, studies on the free-living marine nematode had been largely documented.

1.2.2 General characteristics

The nematodes are also known as round worms. They are ubiquitous, un-segmented, eukaryotic, multicellular and pseudocoelomate worms (Platt and Warwick, 1983; Bird and Bird, 1991; Pechenik, 2000; Rzeznik-Orignac *et al.*, 2004) Most of the nematodes are usually found in cylindrical shape, elongated, smooth together with a complete digestive and reproductive organ. The species mostly found in microscopic size between 50µm to 300µm with their body weight around 0.5^{-1} µg (Platt and Warwick, 1983).

According to Platt and Warwick (1983), the body is essentially a tube within a tube. The external tube is the body wall consists of a cuticle layer and internally a longitudinal muscle

layer. They are unable to elongate the body due to the lacking of circular musculature. The movement is done by alternate contractions of the dorsal and ventral muscle blocks working against the hydrostatic skeleton provided by having a high internal turgor pressure. Due to the flexing dorso-ventral plane, the fixed nematode normally comes to lie on a microscope slide with a lateral side uppermost which is why most illustrations are of lateral views. The vast majorities are transparent and allow their internal anatomy to be seen without the aid of special preparation methods.

Besides that, the internal tube is the gut which is terminal at the anterior but subterminal posteriorly and providing nematode a tail. The gut is differentiated into buccal cavity, a muscular oesophagus (pharynx), an intestine and a shirt rectum. The body wall and gut provide many characters which are useful in identification besides the nervous, excretory and reproductive systems. A fluid-filled cavity called a pseudocoelom is observed between gut and body where the reproductive organs are to be found (Platt and Warwick, 1983).

1.2.3 Feeding

Free-living marine nematodes play an important role in the food chain in the ecosystem due to their high abundance. Most of the literatures on feeding and indeed general ecology of marine nematodes are generated from a paper written by Wieser (1953). The potential food items of the free-living marine nematodes generally include organic detritus, decomposing organisms, bacteria, diatoms, and other living organisms (Platt and Warwick, 1983; Heip *et al.*, 1985). According to Platt and Warwick (1983), the nematodes are showing selectivity in food source. This is proven by using the structure of the buccal cavity as an indicator. The feeding

structure (buccal cavity) of the free-living marine nematode can be divided into four groups: minute form (1A), unarmed form (1B), form with fixed teeth (2A) and form with moveable mandibles (2B). The grouping of the nematodes according to the buccal cavity feeding group is an important criterion for a better understanding and explanation on the food availability (Wieser, 1953; Alongi, 1987a; Gheskiere *et al.*, 2004; Chinadarai and Fernando, 2007; Shabdin and Othman, 2005; Shabdin and Othman, 2008).

Minute form - Nematodes categorized in this group have only a minute or without buccal cavity. They are only able to ingest small particles and/or fluids and namely selective deposit feeders (Platt and Warwick, 1983) (Figure 1.1).

Unarmed form - Those with a buccal cavity but lacking dentition and potentially able to ingest particles of a wider size range including diatoms and are therefore referred to conventionally as non-selective feeders (Platt and Warwick, 1983). However, according to Warwick (1981) (Figure 1.1), some evidence proven that certain nematodes might be selective to look for preferred food item.

Form with fixed teeth - Nematodes in this group also known as epigrowth feeders. They contain small teeth and/or denticles in the buccal cavity which enable cells to be pierced and the contents sucked out or objects scrapped off surface (Platt and Warwick, 1983) (Figure 1.1).

Form with moveable mandibles - Large powerful teeth and mandibles been found and allow predators to seize prey and to swallow and suck the contents (Platt and Warwick, 1983) (Figure 1.1).

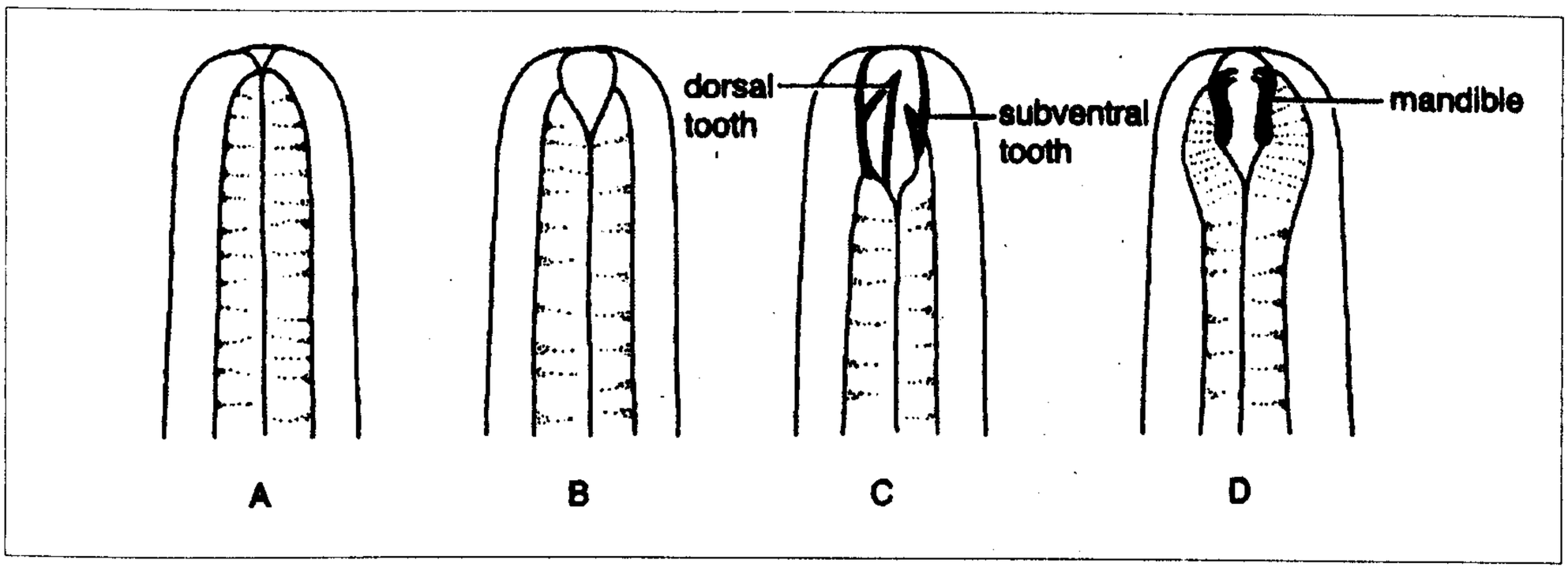

Figure 1.1: Different eulittoral habitats and their nematode populations grouped as trophic guilds: A – Minute form; B – Unarmed form; C – Form with fixed teeth; D – Form with moveable mandibles. (Picture adapted from Platt and Warwick, 1983).

1.2.4 Abiotic factor

1.2.4.1 Salinity

Salinity is one of the parameters that affect the densities of nematode (Moore, 1979; Dye, 1983; Gee and Warwick, 1984; Coull, 1988; Adão *et al.* 2009). Densities of meiobenthos including the nematodes are found decreasing at low salinity area (Hodda and Nicholas, 1986). Besides that, area with extreme salinity will also give physical stress to the nematodes (Moens and Vincx, 2000a). Barnes *et al.* (2008) concluded that salinity is a controlling factor for nematode assemblages in closed coastal lagoons with the evidences of longer – term salinity data. Various authors (Platt, 1977; Alongi, 1987a; Gheskiere *et al.*, 2004; Shabdin and Othman, 2005, 2008; Chinnadurai and Fernando, 2007; Barnes *et al.*, 2008) showed that salinity is positively correlated with the community structure of marine nematode.

Study carried out by Gal'tsova and Platonova (1985) showed that seasonal rains which caused the dilution of seawater did not show any effect on the nematode population. They suggested

that the nematode population could tolerate to the changes of salinity in coastal water backing up the finding of Capstick (1959) where he found that the nematodes had a great toleration with respect to a wide range of salinity. However, Kinne (1964a; 1964b; 1966) and Adão *et* (2009) noted that the changes of the salinity are influencing the nematodes population and distribution pattern. Barnes *et al.* (2008) also found out that salinity was the principal factor correlated with assemblage structure and species diversity where the highest numbers are recorded at higher salinity sites. Adão *et al.* (2009) along the salinity gradient in southern European estuaries showed that the spatial distribution of nematode density, composition, and feeding types appeared clearly related to the salinity gradient.

Only a handful of experimental studies had been carried out on the salinity effects on nematode (Croll and Viglierchio, 1969; Tietjen and Lee, 1972; 1973; Warwick, 1981; Moens and Vincx, 2000a; 2000b). Certain species show higher mortality rate during higher salinity (Moens and Vincx, 2000a). However, Warwick (1981) had proven that with the increase of the salinity, the generation time increases in *Diplolaimelloides bruciei*. According to Moens and Vincx (2000a), contemporaneous salinity is likely to influence species fecundity. Experimental trial on using the *Spilophorella* sp recorded that mother died when suddenly exposed to 50 PSU salinity media, but the larvae change its active mode to become inactive (dormant stage) in the mother uterus (Shabdin and Ekalili, 2008).

1.2.4.2 Temperature

Temperature (overlying/pore water) is one of the factors that affect aquatic organisms. Temperature has a profound effect on minimum generation time T_{min} in all nematodes studied

(Gerlach and Schrage, 1971; Tietjen and Lee, 1972; Heip, *et al.*, 1978; Warwick, 1981). The temperatures of an area will directly affect the metabolism and nematode movement rate (Croll and Matthews, 1977). This kind of impact could mostly be found in temperate areas. The temperature gives a great impact towards the life cycle in temperate areas (Hopper *et al.*, 1973). In general, nematode activities are influenced by the temperature within the range of 10-35 °C (Wieser, 1953) and Hopper *et al.* (1973) found that temperature within the range of 33-35 °C disturbed the reproduction process.

Yodnarasri *et al.* (2008) indicated that nematodes have a seasonal variation in the intertidal zone of the Hichirippu shallow lagoon. Besides that, the air temperature has a direct influence on the temperature of the ground as well as water which the organisms inhabit (Kinne, 1963) and also the multiplication speed of individual species (Orton, 1919; Gerlach and Schrage, 1971). Pavlyuk (2000) noted that temperature indirectly affect the nematode abundance dynamic by stimulating reproduction of certain food organism groups.

The effects of temperature on the nematode species density of the nematodes are found to be correlated (Platt, 1977; Heip *et al.*, 1985; Gheskiere *et al.*, 2004; Shabdin and Othman, 2005; Shabdin and Othamn, 2008). This proves that the temperature is one of the main factors that influence the population of the nematodes zoogeographic distribution in one area. Besides Moens and Vincx (2000a) also mentioned that between optimal and upper lethal temperatures, even slight temperature changes can affect reproductive and metabolic activity. Rzenik-Orignac *et al.* (2003) mentioned that the community of meiofauna including nematode was not structured spatially but temporarily where summer depression of meiodauna observed in

the Brouage mudflat. The variations in nematode abundance also record different over one year (seasonal effect) (Rzenik-Orignac *et al.*, 2003).

1.2.4.3 Dissolved oxygen

Dissolved oxygen (DO) is one of the important factors that affects the density and distribution of nematodes in one area (Tietjen, 1969; McLachlan, 1978). Oxygen is the predominant factor among the abiotic factors in determining the habitat conditions and the presence of meiobenthos. Meiobenthic organisms have relatively large surface areas and mostly high oxygen demands; only a few specialized forms will prefer hypoxia conditions and it prove that the distribution of the most meiobenthos communities can be correlated to the oxygen supply of the pore water (Giere, 2009). However, the decreasing of DO in the seawater does not affect much on the nematodes yet oxygen is still needed to survive (McLachlan, 1978). However, certain species such as *Terschellingia longicaudata* is usually found tolerate with the anoxic condition compared to the other species (Rzenik-Orignac *et al.*, 2003). In certain aspects, the redox potential together with the anoxia layer (hydrogen sulfide) in the ecosystem are affecting the community structure of marine nematode (De Beer *et al.*, 2005; Weber *et al.*, 2007).

1.2.4.4 Grain size

When describing habitat of meiobenthos especially nematodes, grain size is a key factor since it directly determines spatial and structural conditions which indirectly determine the physical and chemical milieu of the sediment. Warwick *et al.* (1998) stated that species richness and

diversity varies among habitats, being greatest in sandy beaches with over one hundred species being typical while in muddy site and in algal communities, the number of species is more typically in the range of 30 - 70. The density of the nematode was higher in the muddy sediment compared to the sandy sediment (Capstick, 1959; Teal and Wiser, 1966; Hodda and Nicholas, 1986). According to Steyaert *et al.* (2003) and Adâo *et al.* (2009), the predominance of sandy sediments contributes to a decrease in density and an increase in diversity.

In additional, sediment heterogeneity and organic content are important to govern the species diversity (Liu *et al.*, (2008). The increase of the size, the grain shape also determines the sorting of the sediment. Angular, splintery articles are packed tighter than spherical ones. A higher angularity leads to more structural complexity, less water permeability and usually higher abundance of meiobenthos (Conrad, 1976; Adâo *et al.*, 2009). Grain size is determined to be the major factor influencing the species diversity of nematodes along the Sarawak coastal waters (Shabdin, 2006a). Epigrowth feeders are present more abundantly in sandy sediments while deposit-feeders are predominant in finer sediments (Chinnadurai and Fernando, 2007).

1.2.5 Biotic factor

1.2.5.1 Total organic matter

According to Bale and Kenny (2005), the organic matter component is important in ecological study. The study of the total organic matter (TOM) is required as the indicator of the biology residue within, or on, the sediment system. Buchnan (1984) mentioned that the total organic matter can be obtained by the loss weight on ignition at 600°C of a dried sediment sample

from which the carbonates have been previously removed by acid treatment. The content of the sediment can provide an insight into sediment cohesion, information on the potential nutritional value to deposit feeder, and on the oxygen demand within the sediment (Bale and Kenny, 2005). Ansari *et al.* (1983) claimed that higher organic matter contributes to lower dissolved oxygen of an environment. A strong correlation of *Terschellingia longicaudata* with organic matter suggests an environmental relation between the two where a large amount of organic matter often results in organic matter decay, anoxic conditions and high bacteria development (Rzezṇik-Orignac *et al.*, 2003). This indicated the role of the organic matter as the food source for certain species of nematodes as they are found in anoxic conditions and feed on bacteria (Wieser, 1953; 1960; Rzeznik-Orignac *et al.*, 2003).

1.2.5.2 Chlorophyll (Primary producer)

Phytoplankton is the key of photosynthetic molecule and is measured as a proxy for photosynthetic biomass both in water column, on the surface of intertidal sediment or sub-tidal sediment within the photic zone (Bale and Kenny, 2005). According to Paterson (1989; 1997) the microphytobenthic population provides much of energy for epibenthic grazers and also influences the stability of the sediment through the production of the mucopolysaccharides which is also known as extracellular polymeric substance (EPS).

Phytobenthos includes all of the associations of organisms involved in the primary production and living at or closely associated with the many solid/liquid interfaces. The bulk of the photosynthetic occurs in the intertidal and shallow subtidal regions where both photosynthetic and chemosynthetic associations are involved. The primary producers live on or in the silt,

sand or rocks attached to the microscopic algae, angiosperms and animals associated with these interfaces or even on the under surface of permanent sea ice. Moeń and Vincx (1997) observed that diatoms are clearly an important food source. Diatom was recorded to be the food source for several studied marine nematode species such as the *Daptonema oxycerca, Daptonema setosum* and others (non-seletive deposit feeder) where commonly have up to 40 or more diatom frustules in their intestine (Rzeznik-Orignac *et al.*, 2003). An increasing of chlorophyll *a* concentration in studied months increase the grazing rate of the marine nematode (Yodnarasri *et al.*, 2008).

1.2.6 Synecological perspectives

1.2.6.1 Community structure and diversity

Community structure can be defined as the structuring of the benthic assemblages where the species richness richness (biodiverisity, alpha-diversity) together with the ecological diversity are regulated by both ecological and physical process. Several criterias are important when dealing with the ecological study such as the area of investigation (exposed *vs* sheltered habitats), the taxonomic and ecological nature of the studied animals (opportunists vs specialist) and also the used method (life *vs* fixed; sieving vs sorting) (Giere, 2009).

Different factors are recorded to influent the the structuring of nematodes in different environment. However, competitive interactions may induce instabilities in conflicting population and ultimately cause the amensalism of the less competitive species. The biotope stability is potentially reducing the diversity (Rhouds and Young, 1970; Woodin and Jackson, 1979; Warwick *et al.*, 1986).

Patchiness of nematodes might be influenced by the minute habitat heterogeneities, temporal variations and food web interaction (Warwick *et al.*, 1990). Schratzberger *et al.* (2002) mentioned that small oscillations reduce the intensity of competitive displacement and tent to enhance diversity, severe disturbances negatively affect diversity which showed that the reduction of the species diversities due to the disturbances on the habitats (pollution). Certain species of nematodes such as *Sabatieria pulchra* can occur in high density of certain low-diversity communities (Modig and Ólafsson, 1998).

Carney (2007) discussed a comprehensive account of the development and use of diversity estimation in benthic communities. Several papers related to the studies of diversity had been published (Platt *et al.*, 1984; Heip *et al.*, 1988; Crisp and Mwaiseje, 1989). Hillebrand *et al.* (2007) showed that the grazing reduced the species richness; fertilization reduces evenness while the assemblages reacted differently in terms of species richness depending on the degree of evenness. The Shannon-Wiener diversity index (Shannon and Weaver 1949) is the most widely used measure using the benthic community diversity (Clarke and Warwick 1994) to indicate sediment condition. According to Lewis (2005), sediment quality is considered poor if the index value was 2.0 or less based on a frequency distribution of Ponar diversity values reported by Friedman and Hand (1989).

Currently, it is still not conclusively to explain which factor or factorial combination responsible for the high diversity of the nematodes (Herman and Vranken, 1988; Finlay *et al.*, 1996). Several questions occurred nowadays in determining the accuracy of the data and some even questioned the appropriate of the traditional diversity indices such as the Shannon-

Weiner diversity index (H'), rarefaction calculations and with their inherent impairment by equitability, sample size and local features (Boucher and Lambshead, 1995; Gray, 2000; Lambshead and Boucher, 2003).

1.2.6.2 Abundance

The abundance of the meiobenthos varies greatly but McIntyre (1969) reported the range of between 30-30,000 ind. / 10 cm^2. According to Coull and Bell (1979), if 1,000-2,000 ind. / 10 cm^2 can be assumed to be an average value integrated over all habitats, the meiobenthos would exceed the macrofauna in abundance by two to three folds. Warwick *et al.* (1998) stated that species richness and diversity of nematodes vary among habitats, being greatest in sandy beaches with over one hundred species being typical while in muddy site and in algal communities, the number of species is more typically in the range of 30 - 70.

1.2.7 Pattern of distribution

1.2.7.1 Horizontal distribution

Along the slopes of shores, tides account for the large-scale zonation of meiobenthos (Hulings and Gary, 1976) and controlling the grain size composition, water content, salinity, and permeability which factors such as oxygen supply secondarily depend upon. An example of sandy shores of North Sea, the meiobenthos abundance is highest close to the mid-tidal level. While in less exposure to the muddy sediments, greatest abundance of meiobenthos and species richness is recorded near the low-tide level. The swash zone, with marked physical and biological variations displayed lower meiobenthos densities under strong tidal

Lower meiobenthos abundance and diversity are recorded at the upper areas of the eulittoral and supralittoral (Giere, 2009).

Several studies (Heip *et al.*, 1985; Snelgrove and Butman, 1994; Li *et al.*, 1997; Somerfield *et al.*, 2007; Giere, 2009) showed that the small scale distribution appears to be mostly due to biotic interrelations. It is believed to be influenced by a complex factorial combination of attraction such as reproductive activities or predation. Most of the patchy distribution is determined by aggregations of microorganisms, selective feeding preferences and direct or indirect trophic interactions (Findlay, 1981; Fleeger *et al.*, 1990; Blanchard, 1991).

According to Ólafsson *et al.* (1999), larger patches of food such as decaying macrofauna can also structure the distribution of many meiobenthos through selective attraction. Giere (2009) judged that the organic content of sediments (as a biogenic bulk parameter) is another decisive factor and seems to play a key role in meiobenthos density and distribution which was similar to the study of McLachlan *et al.* (1981) and Moreno *et al.* (2006). In many cases, the food availability overrides the abiotic parameters in the distribution importance. Sublittoral and deep-sea bottom with lower concentration of food accounts showed a reduction in the meiobenthos abundance and generally 3-4 times scarcer than in tidal bottoms (Vanreusel *et al.*, 1995).

1.2.7.2 Vertical distribution

The vertical distribution of nematodes in sediments has attracted much attention since the development of the sulphide system concept. As originally defined, the sulphide system is the

anaerobic environment typically established under a cover of oxidized aerobic sediments (Fenchen and Riedl, 1970). However, according to Heip *et al.* (1985), the sulphide biome or thiobios was subsequently renamed by Boaden and Platt (1971) is bounded at its top by the redox discontinuity layer where oxidized process replaced by the reducing process.

Different approaches occurred when Giere (2009) using the oxygen and food supply in the profiling the vertical distribution of the meiobenthos including the nematodes. The upper few centimeters have a richer supply of oxygen and good particles and so harbor more meiobenthos than the deeper zone. Grain size also showed an influence on the meiobenthos abundance where Yingst (1978) found that 71% of the meiobenthos occurred in the 2 cm uppermost of the silty sediments. Smith and Coull (1987) showed that the high concentration of organic matter in the muddy area consist of higher abundant of meiobenthos in the uppermost centimeter. Certain aspects such as the macrofauna burrow and also the plant root seems to be major reasons for deep vertical distribution (Giere, 2009).

Joint *et al.* (1982) showed that the vertical migration along a gradient system, with preference and avoidance reactions to tidal change. The powerful "tidal pumps" have massive influence on fluctuations in the vertical distributions. Studies related to the vertical migration of the nematodes and meiobenthos downwards during the tidal, temperature, water content and salinity (Boaden, 1968; Boarden and Platt, 1971; Harris, 1972; Foy and Thistle, 1991; Shabdin and Othman, 2005) suggest an active reaction to the hydrodynamic conditions and vibrational stimuli.

Temperature regime can also influence the vertical occurance of the meiobenthos such as the upward nearer to the surface during the summer but migrate further down during winter (Giere, 2009).

1.2.8 Environmental perturbance

The assessment of ecosystem health using the meiobenthos is getting more preference by the researchers nowadays. The impact studies using the meiobenthos are acknowledged and had now been accepted by international government agencies. Monitoring programmes and case studies performed after both natural and man-made disturbances had shown that the resolution can be improved by studying meiobenthos because of its commonly high sensitivity and the turnover compared to those of macrobenthos (Sommerfield and Warwick, 1996).

However, controversies still occurred in using the meiobenthos such as the nematodes and copepods in the pollution studies. Studies by Heip (1980), Herman *et al.* (1985), Bodin (1988), Josefson and Widbom (1988), Austen *et al.* (1989), Warwick *et al.* (1990), Austen and Widbom, (1991), Hicks (1991) and Warwick (1993) showed different point of views in using the meiobenthos in pollution studies. The advance of the technologies had improved the potential use of meiobenthos in pollution studies especially after several achievements showed by Somerfield and Warwick, (1996), Diederich *et al.* (2000), Staton *et al.* (2001), Chandler (2004), Bejarano *et al.* (2006a, 2006b), Neher and Darby (2006), Vassalo *et al.*, (2006), Kammenga *et al.* (2007), and Wells (2007).

1.2.9 Nematodes (meiobenthos) in tropical region

1.2.9.1 Tropical region

McIntyre (1968) and Coull (1970) lead the studies of the meiobenthos in subtropical and tropical regions. In review of the tropical meiobenthos, Alongi (1990a) outlined a picture with large geographical, biotropical and seasonal variations. The tropics have greater range of meiobenthos, with the carbonate sands on beaches, shelf regions of carbonate sand, estuarine muds, mangrove thickets, and enclosed lagoons. In oligotrophic tropical seas, the abundance of the littoral meiobenthos in the tropics is very similar to that in temperate coastal areas (from several hundred to several thousand specimens per $10cm^2$) (Alongi, 1990b; Vanhove, 1993). Giere (2009) showed that the dense populations beyond the range of (more than 10,000 per cm^2 in Malaysian coast and 17,000 nematodes per $10cm^2$ in Indian salt marsh).

Table 1.1: Records for the study of nematodes in tropical region.

Country	Scope	References
Malaysia	Ecology	Sasekumar, 1994; Shabdin, 1998, 2006a; Shabdin and Othman, 1999, 2005, 2008; Chen and Shabdin, 2008, 2009
Vietnam	Ecology and taxonomy	Doan and Nguyen, 2000; Gagarin and Nguyen, 2004, 2006a,2006b; Gagarin *et al.*, 2005; Nguyen *et al.*, 2005
India	Ecology	Rao and Misra, 1983; Chinnadurai and Fernando, 2007; Nanajkar and Ingole, 2010

1.2.9.2 Seasonal pattern

Yearly fluctuations of nematode density and species composition in tropical region had been studied by a numbers of authors (Heip *et al.*, 1985) and under the tropical conditions the density fluctuations often also exhibit a seasonal pattern. Seasonal studies of marine nematode had been practiced for decades in tropical region (Coull, 1970; Westheide, 1981; Faubel, 1984; Arlt, 1993; Shabdin and Othman, 2005).

However, in contrast to the temperate climates, the richest populations often develop in cooler parts of the year (Alongi, 1990b). In certain aspects such as the breeding and reproductive also showed a seasonal pattern and are often adjusted to avoid climatic extremes such as torrential rainfalls in the monsoon season. Suresh *et al.* (1992) and Nozais *et al.* (2005) claimed that the monsoonal floods with their high mud loads of river run-off, hurricanes (so call typhoons) and cyclones which are characteristic of the tropical girdle can cause a sudden or sometimes complete turnover of the ecosystem with severe destructive in the nematode assemblages. "El Niño" effects or the seasonal upwelling in certain tropical regions have an impact on coastal nematode due to the enrichment of the nutrient and will increase the abundance of certain species unless reaching the anoxic events. Besides that, the salinity and temperature stress also seems to affect the abundance of nematode community in tropical region (Alongi, 1990b).

2.0 MATERIALS AND METHODS

The project consisted four parts: (1) survey on marine nematode along the Sarawak coastal waters, (2) horizontal profile study of marine nematode in Teluk Awar, Muara Tebas, Sarawak (3) vertical profile study of marine nematode in Teluk Awar, Muara Tebas, Sarawak and (4) the seasonal study of the marine nematode in Teluk Awar, Muara Tebas, Sarawak.

2.1 Field sampling

2.1.1 Survey on marine nematode along the Sarawak coastal waters

The study was carried out along the Sarawak coastal water including both marine and estuarine sites starting the October of 2007 until May 2009. The twenty study sites was Punang River (site 1), Engriting Beach (site 2), Limbang River (site 3), Limbang Beach (site 4), Lutong River (site 5), Miri Beach (site 6), Niah River (site 7), Niah Beach (site 8), Similajau River (site 9), Similajau Beach (site 10), Mukah River (site 11), Mukah Beach (site 12), Batang Lassa Daro (site 13), Kuala Matu Beach (site 14), Sg Jerijih (site 15), Tanjung Manis Intertidal (site 16), Kabong River (site 17), Tg. Kembang Beach (site 18), Sematan River (site 19) and Batu Mandi Sematan (site 20) (Figure 2.1; Table 3.1).

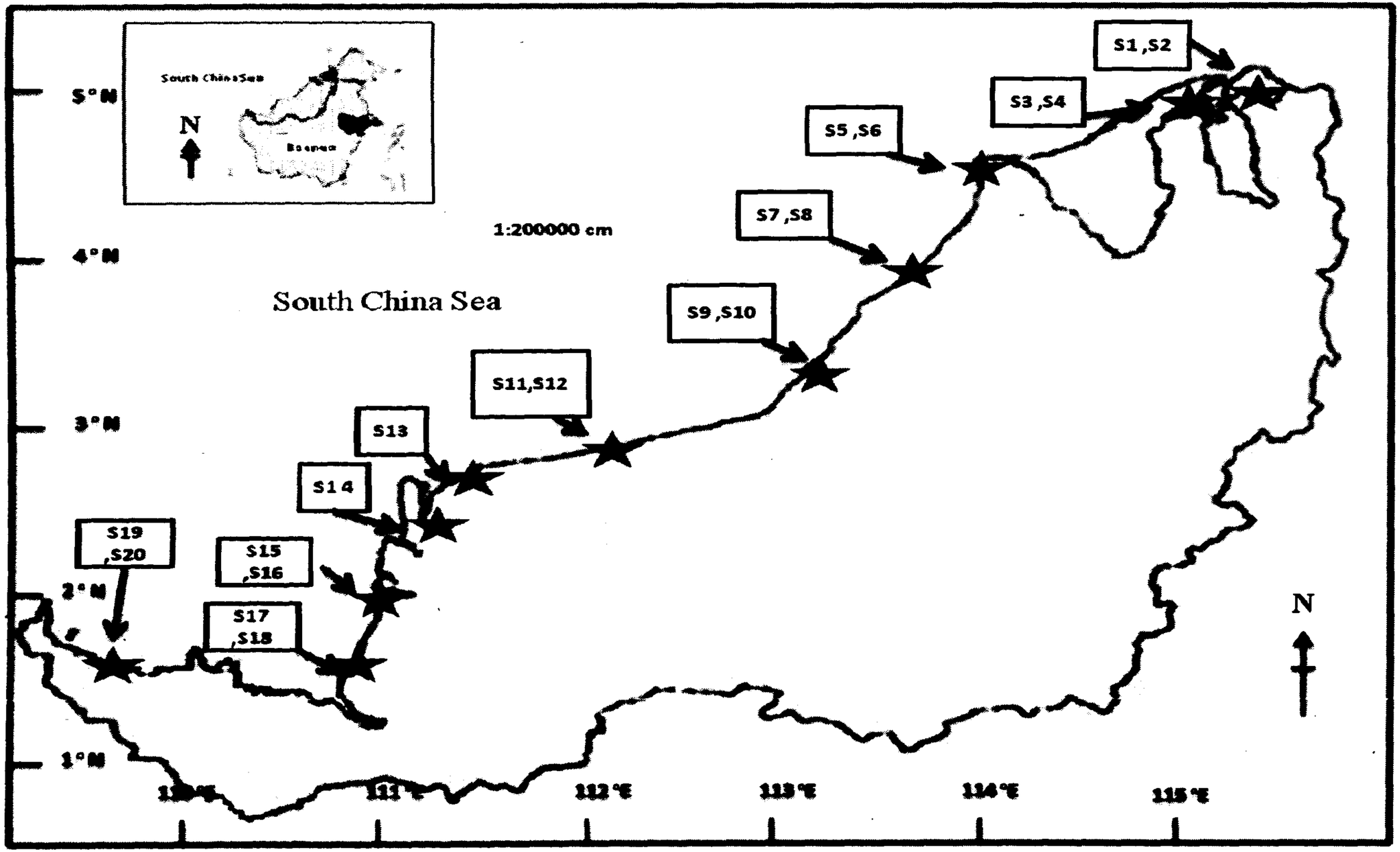

Figure 2.1: The location of the sampling sites along Sarawak coastal waters.

Physico-chemical parameters of the water (salinity, temperature, dissolved oxygen, and pH) were measured *in situ*. The measurement was done in every station for both marine and estuarine using the multiprobe meter - HORIBA U20-XD.

The perspex corer with the inner diameter of 2.5 cm was used to take the sediment. Two cores of sediment at a depth of 5 cm were taken at each station for the nematodes density study. Samples were labeled and brought back to the laboratory for further analysis. One core of sample was collected for the particle size analysis.

2.1.2 Horizontal and vertical study of marine nematode at Teluk Awar

Horizontal and vertical studies were conducted at Teluk Awar, Muara Tebas, Sarawak. Teluk Awar was chosen as a study site due to the presence of wide sandy and muddy habitats and easy accessibility from Kuching City. The coordinate of the study site was N 01°39.816' E 110°28.500' (Figure 2.2). In general, site A and site B were not categorized as a sandy or muddy site as the particle fractions changed when moving outward from the high tide to the subtidal area. However, mangrove species such as *Avicenia marina*, *Rhizophora mucronata*, *Rhizophora apiculata* and *Casuarina equisetifolia* were recorded in site B.

The distance of the Mean High Water Neap (MHWN) to the Mean Low Water Neap (MLWN) level was recorded approximately 2.8 km. Seven quadrates (station 1 to 7) were placed along transect from the MHWN to the MLWN level. Two more quadrates were placed in the sublittoral zone (station 8 and 9).

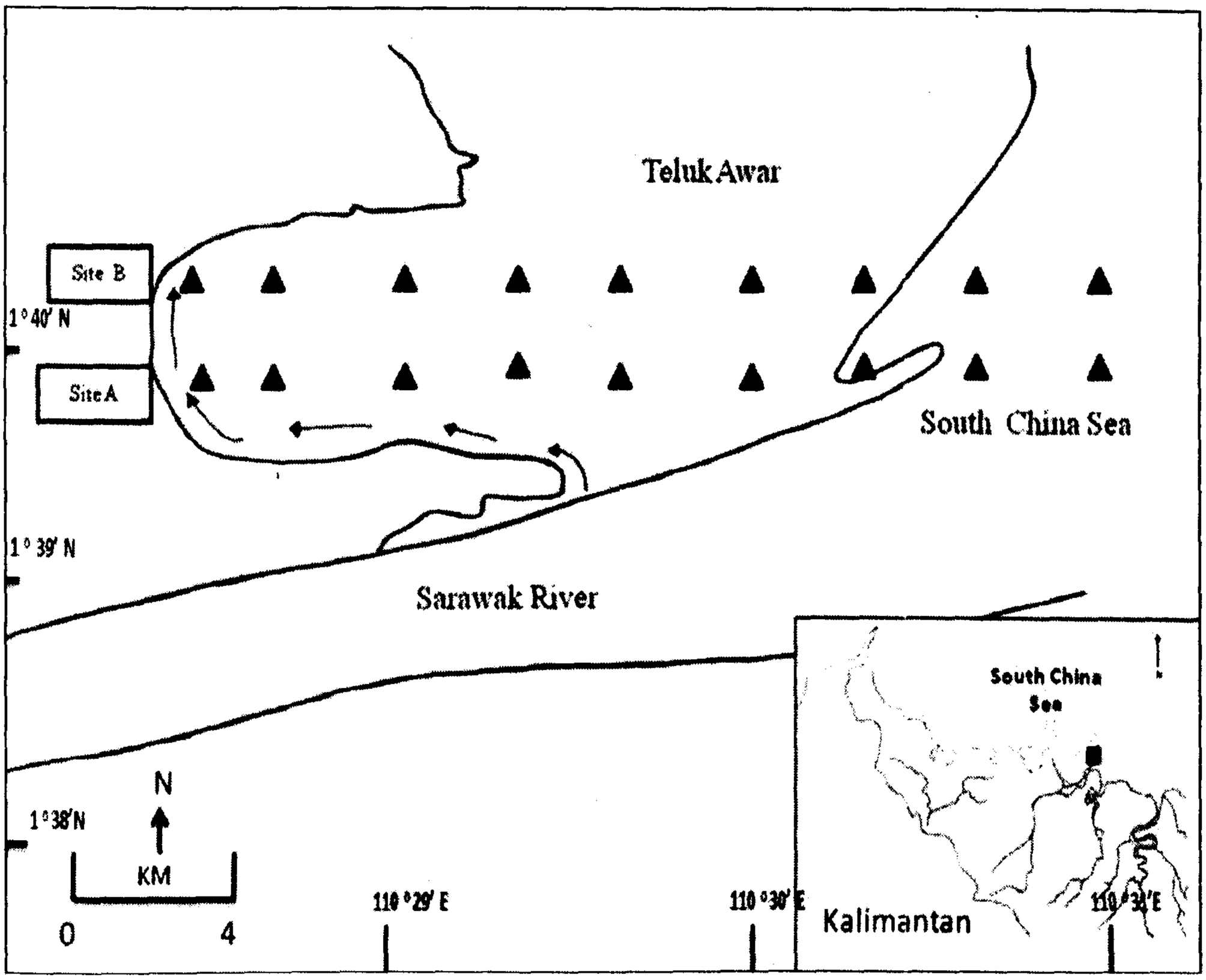

Figure 2.2: Location of sampling site in Teluk Awar. Arrow represents the influx of freshwater from Sarawak River.

A pilot study had been carried out on the 17th June 2008 to have a better understanding on the study site. Five replicates of samples were taken back for nematode density study. Each replicate samples were taken in the depth of 20 cm. The statistical results showed that 3 replicates were strong enough to represent the nematode density of each station. Fifteen cm were found more than enough for the marine nematode study as zero nematodes were found below the 15 cm depth in all the replicates. Two replicates of sediment samples were taken for Total Organic Matter (TOM) analysis and three replicates for chlorophyll *a* analysis. One core of sediment samples was taken for the particle size analysis.

The sampling in present study was carried out on the 23rd July 2008. A quantitative sampling of sediment was carried out using Perspex tube corer of a known cross-sectional area (2.5 cm) at each site. Nematodes were sampled at nine stations (site A and site B) during the low tide (15 cm depth). Seven stations located in the intertidal while the other two stations located in the subtidal area. SCUBA techniques were used in collecting the samples from the subtidal area. A piston style corer was used to collect the sediment samples in subtidal stations. The distance between each station from the Mean High Water Neap (MHWN) was approximately 400 m to subtidal area (station 8 and 9). Three randomly located replicate samples were extracted from the sediments. Each sediment core was immediately fixed in 5% formalin which was diluted using the site water.

The same corer was used to obtain six additional replicate of samples from each station to determine the total Organic Matter (TOM) (2 replicates), chlorophyll *a* (chl *a*) (3 replicates) and particle size (1 replicates). Samples were stored immediately in cooler box and brought back to laboratory for further analysis.

At each intertidal station, the pore water was extracted (a hole was dug to accumulate the pore water) and the physico-chemical parameters (pH, salinity, dissolved oxygen (DO), and temperatures) were measured *in situ* using the HORIBA U20-XD. For the two subtidal stations, the physico-chemical of overlying water of the sediment was measured *in situ* using the same equipment as in intertidal stations.

2.1.3 Seasonal study of marine nematode at Teluk Awar

The seasonal study was done in Teluk Awar, Sarawak. Two stations (sandy and muddy) were chosen for the seasonal study where samples were collected monthly (Figure 2.2). The sampling period started from July 2008 until October 2009. A total of 16 months monitoring was conducted. A pilot study had been carried out on the 17th June (as described in Section 2.1.2).

The sampling started on the 23rd July 2008 and samples were collected monthly. The sandy site which had been chosen was the station 2 of site A (Figure 2.2). The location of the muddy site was dominated by the mangrove species such as *Avicenia marina*, *Rhizophora mucronatal*, *Rhizophora apiculata* and *Casuarinas equisetifolia* which was the station 2 of site B (Figure 2.2). Three randomly located replicate samples were extracted from the sediments as mentioned in 2.1.2. Each sediment core was immediately fixed in 5% formalin which was diluted using the site water. The same corer was used to obtain six additional sediment samples for TOM, chl *a* and particle size. Physico-chemical parameters such as pH, salinity, DO and temperatures were measured *in situ* using multiprobe meter - HORIBA U20-XD.

2.2 Laboratory analysis

2.2.1 Sediment analysis

Sediment analysis was conducted using the Bale and Kenny (2005) and Buchanan (1984) method. After initial splitting of silt-clay fraction (Buchanan, 1984), the retained sediments on the 63 μm sieves was transferred for further process (dry sieving method) described by Bale and Kenny (2005). Suspension in the pan and basin were transferred for pipette method based on the Stokes' Law (Buchanan, 1984) to determine the silt and clay percentage.

2.2.2 Total organic matter and chlorophyll *a*

TOM samples were measured according to the method proposed by Greiser and Faubel (1988) method. The analytical method involved drying the samples at low temperature, then combusting the organic content at high temperatures. The temperatures for the combustion were about 450-500 ˚C to avoid volatilizing bicarbonates.

Chl *a* analysis conducted based on Wasmund (1984) method. Chl *a* content obtained using the equation given by Jeffrey and Humprey (1975).

2.2.3 Nematode extraction

Nematodes extraction and preservation were done according to the methods described in Sommerfield *et al.* (2005). Nematodes were picked out from the samples and put in anhydrous glycerol on a microscopic slide. The slide was later observed under a high

magnification microscope (Zeiss MC 80 DX) and identified using the pictorial keys (Platt and Warwick, 1983, 1988; Warwick *et al.*, 1998). Each nematode species was assigned to one of the four following functional feeding groups (FFG) designated by Wieser (1953) on the basis of buccal cavity morphology. 1A - Selective deposit feeders (species without a buccal cavity or with only a narrow tubular buccal cavity and inject the particles of bacterial size). 1B - Non-selective deposit feeders (species with a large buccal cavity and not armed with any teeth). 2A - Epigrowth or diatom feeders (species having a buccal cavity armed with small or moderate sized teeth). 2B - Predators or omnivores (species with large teeth and jaws) (Figure 1.1).

2.3 Statistical analysis

Data were analyzed in order to (a) compare each of the distribution patterns of the environmental factors between stations (high tide to sub-littoral), (b) characterize the nematode communities' distribution along the stations with the explanations on their composition, density and feeding group. The statistical analysis in the current study was based on the modification from the methods described in Hourston *et al.* (2009).

2.3.1 Environmental variables

One-way Analyses of Variance (ANOVA) were performed to determine whether the following environmental and biotic variables differed significantly among the stations using the site as fixed factor. The environmental variables that tested were temperature (^{o}C), TOM, chl *a* concentration, DO, pH and also densities of each site. The H_0 for all the ANOVAs

where the significant difference did not occur among the tested groups was rejected if the (p) <0.05.

Analysis was conducted using the PRIMER v6 statistical package (Clarke and Gorley, 2006) on the environment parameters (between site and stations). The purpose of conducting the tests was to determine whether the environmental condition differed significantly among sites, stations or seasons.

The percentage of the sediment particle size fractions in each station of each site was obtained and analyzed using the Principal Component Analysis (PCA) to determine visually the extent of any difference of the particle fractions in each studied sites' stations to provide a visual graphic result.

2.3.2 Species compositions among stations and sites

The mean densities of the nematode species were used to determine the species richness (Margalef): d=(S-1)/Log (N), Shannon-Weiner species diversity index and Pielou's evenness: J'=H'/ Log_2 (S). *d – species richness; N – total individuals; S – total species; J' – Pielou's evenness; H' – Shannon-Weiner species diversity index.

The mean densities of the nematodes were then subjected to group-averaged hierarchical cluster analysis and non-metric multidimensional scaling (nMDS). An analysis of similarity was conducted to determine the similarity status for both sites and stations.

2.3.3 Relationship between nematode abundance and environmental variables

A test was conducted on the environmental variables (salinity, DO, temperature, pH, chl *a*, and TOM) and the nematode species abundance to determine the best pairing or combination of the environmental variables to the nematode abundance.

The nematode species was divided into the four FFG. PCA had been conducted on the percentage of functional feeding groups to explore the dominancy.

3.0 RESULTS

3.1 Coastal study

3.1.1 Physico-chemical parameters of water

The survey consists of 20 sites (marine and estuarine) along the Sarawak coastal waters. Four parameters (pH, DO, temperature and salinity) were recorded *in situ* during the sampling. The studied stations were represented by the site numbering (1-20) which eased the interpretation. The detailed of the representative number for each site together with the GPS reading were listed in Table 3.1. One-way ANOVA analyses showed that all the physico-chemical parameters were significantly different between sites (p-value < 0.05) (Appendix A1). The pH of the present study was recorded to have two distinct patterns due to the geographical difference. Most of the sites at the northern part of Sarawak coastal waters except Engriting Beach, Lutong River and Miri Beach were recorded to be more acidic (pH <7) while the sites in the southern part of Sarawak coastal (starting from Jerijih River until Sematan Batu Mandi) were recorded to be slightly alkaline. Generally, the pH value was recorded within the range of 6.8-7.3. However, the northern part of Sarawak coastal waters (Punang River, Limbang River and Limbang Beach) were observed to have lower pH reading (6.2-6.4) compared to the others.

All the DO readings for the study sites were recorded to be high as the samples collected either in the running water river or at the sublittoral area. Highest reading of temperatures been observed in Niah Beach (36.07 °C) while lowest at Lutong River (27.03 °C). Salinity was recorded to be different due to the geographical location of the sampling sites (marine or estruarine). Details on the abiotic readings referred to Table 3.2.

Table 3.1: Site numbering for coastal survey together with the GPS reading.

Site	Site Name	GPS Reading
S1	Punang River (Estuary)	N 04° 53.017' E 115° 20.264'
S2	Engriting Beach (Marine)	N 04° 54.512' E 115° 22.317'
S3	Limbang River (Estuary)	N 04° 50.195' E 115° 00.153'
S4	Limbang Beach (Marine)	N 04° 51.172' E 115° 02.122'
S5	Lutong River (Estuary)	N 04° 28.086' E 113° 59.788'
S6	Miri Beach (Marine)	N 04° 23.143' E 113° 59.524'
S7	Niah River Estuary (Estuary)	N 03° 58.636' E 113° 42.549'
S8	Niah Beach (Marine)	N 03° 57.652' E 113° 41.701'
S9	Similajau River (Estuary)	N 03° 30.954' E 113° 18.110'
S10	Similajau Beach (Marine)	N 03° 31.980' E 113° 17.622'
S11	Mukah River (Estuary)	N 02° 54.598' E 112° 05.390'
S12	Mukah Beach (Marine)	N 02° 54.671' E 112° 05.034'
S13	Batang Lassa Daro (Estuary)	N 02° 31.106' E 111° 23.632'
S14	Kuala Matu Beach (Marine)	N 02° 42.740' E 111° 27.391'
S15	Jerijih River (Estuary)	N 02° 08.437' E 111° 11.340'
S16	Tanjung Manis Intertidal (Marine)	N 02° 08.119' E 110° 10.265'
S17	Kabong River (Estuary)	N 01° 47.486' E 111° 06.492'
S18	Tg. Kembang Beach (Marine)	N 01° 49.250' E 111° 05.833'
S19	Sematan River (Estuary)	N 01° 47.760' E 109°47.292'
S20	Sematan Batu Mandi (Marine)	N 01° 52.657' E 109° 45.587'

Table 3.2: Mean of physico-chemical of the water variables, standard deviation (SD) and the percentage of particle size fractions for the study of Sarawak coastal waters.

Site	Name	pH	SD	DO (mg/l)	SD	Temperature (°C)	SD	Salinity (PSU)	SD	Sand%	Silt%	Clay%
S1	Punang River (Estuary)	6.45	±0.03	1.84	±0.05	30.33	±0.15	23.00	±1.00	75.51	19.63	4.86
S2	Engriting Beach (Marine)	7.37	±0.16	5.38	±0.04	29.40	±0.00	35.00	±0.00	94.82	4.35	0.84
S3	Limbang River (Estuary)	6.56	±0.07	5.16	±0.04	30.80	±0.00	20.33	±2.08	3.28	78.38	18.34
S4	Limbang Beach (Marine)	6.28	±0.01	4.74	±0.03	28.80	±0.00	25.67	±3.22	5.74	70.95	23.31
S5	Lutong River (Estuary)	7.03	±0.01	6.87	±0.06	27.03	±0.21	26.00	±1.00	52.36	33.15	14.49
S6	Miri Beach (Marine)	7.04	±0.01	7.02	±0.04	32.00	±0.17	29.00	±0.00	98.72	1.02	0.26
S7	Niah River (Estuary)	6.93	±0.00	5.04	±0.08	27.67	±0.06	19.00	±1.00	97.37	2.62	0.00
S8	Niah Beach (Marine)	6.96	±0.07	6.04	±0.22	36.07	±0.21	24.67	±3.22	94.45	4.62	0.93
S9	Similajau River (Estuary)	6.91	±0.01	6.58	±0.08	30.50	±0.00	28.00	±0.00	27.35	54.20	18.44
S10	Similajau Beach (Marine)	6.93	±0.01	9.42	±0.02	30.17	±0.15	31.67	±1.53	97.36	2.18	0.46
S11	Mukah River (Estuary)	6.93	±0.00	3.33	±0.04	26.37	±0.06	20.33	±1.53	97.33	1.45	1.23
S12	Mukah Beach (Marine)	6.92	±0.01	7.93	±0.08	33.13	±0.15	29.00	±0.00	94.20	4.40	1.39
S13	Batang Lassa (Estuary)	6.81	±0.14	4.95	±0.18	26.63	±0.12	21.00	±1.00	16.31	64.86	18.83
S14	Kuala Matu Beach (Marine)	6.92	±0.01	6.78	±0.21	32.30	±0.00	20.00	±0.00	86.52	10.08	3.40
S15	Jerijih River (Estuary)	7.31	±0.01	12.24	±0.07	29.90	±0.00	30.00	±0.00	98.60	1.07	0.33
S16	Tanjung Manis (Marine)	7.70	±0.00	12.43	±0.32	30.00	±0.00	33.00	±0.00	98.13	1.04	0.83
S17	Kabong River (Estuary)	7.61	±0.01	4.09	±1.07	28.77	±0.153	28.50	±0.50	34.83	57.68	7.49
S18	Tg. Kembang Beach (Marine)	7.63	±0.01	5.78	±0.01	33.07	±0.058	25.50	±0.50	97.98	1.51	0.51
S19	Sematan River (Estuary)	7.68	±0.00	11.93	±0.51	27.30	±0.000	32.00	±0.00	70.58	24.71	4.70
S20	Batu Mandi Sematan (Marine)	7.60	±0.00	11.60	±0.95	27.30	±0.000	33.00	±0.00	80.96	17.96	1.08

* DO – dissolved oxygen

Results of the PCA derived from the mean percentage of the particle size fractions showed that site (3, 4, 5, 9, 13 and 17) were dominated by the silt while site 1 and site 20 by the particle fractions of 1mm (Figure 3.1). Particle size analysis showed that site 2 and site 12 were dominated by very fine sands (0.063 mm). Others were recorded to be dominated by fine sands (0.125 mm).

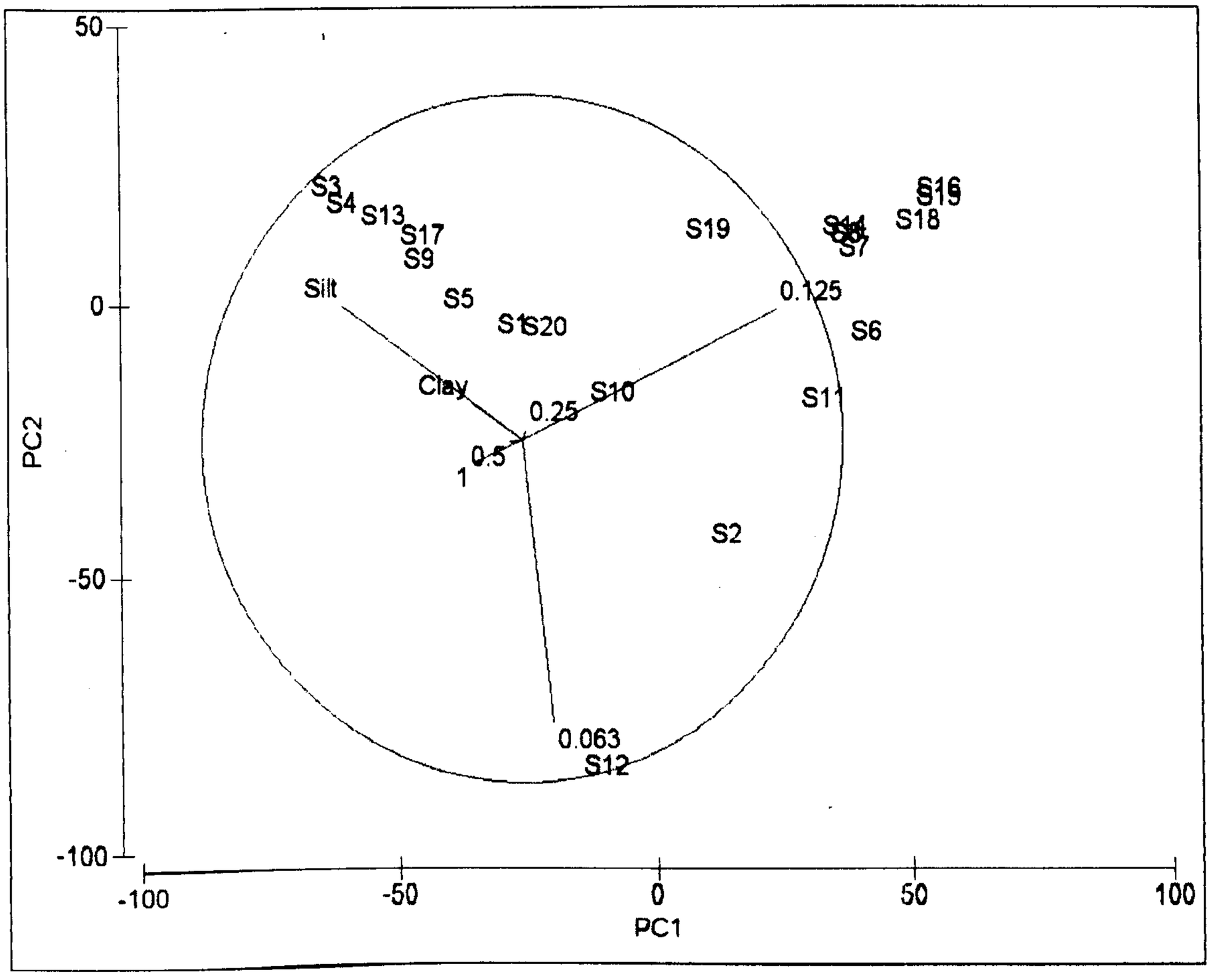

Figure 3.1: Principal component analysis derived from the mean percentage of the particle fractions for each studied site. PC 1 and 2 accounted for 85.3 % of the total variation present.

3.1.2 Nematode community structure

A total of 87 species was recorded along the Sarawak coastal waters (Appendix E1). Different sites were observed to have different pattern of marine nematode density and species richness (Figure 3.2, 3.3, 3.4 and 3.5). Miri Beach was recorded with the highest abundant of marine nematode and species number followed by Sematan River. Zero marine nematode was recorded in the samples taken back from Limbang Beach and Mukah River. The highest number of species was recorded in Miri Beach, Sematan River and Lutong River. The results of Shannon-Wiener species diversity index were recorded to be low. Most of the studied sites showed on the diversity index lower than 2.0 except for Lutong River and Miri Beach. Pielou's evenness for the coastal sites dropped from the Punang River to Limbang Beach at the northern part of Sarawak. Most of the remained sites having were among the range of 0.6 - 0.9 except for Mukah River.

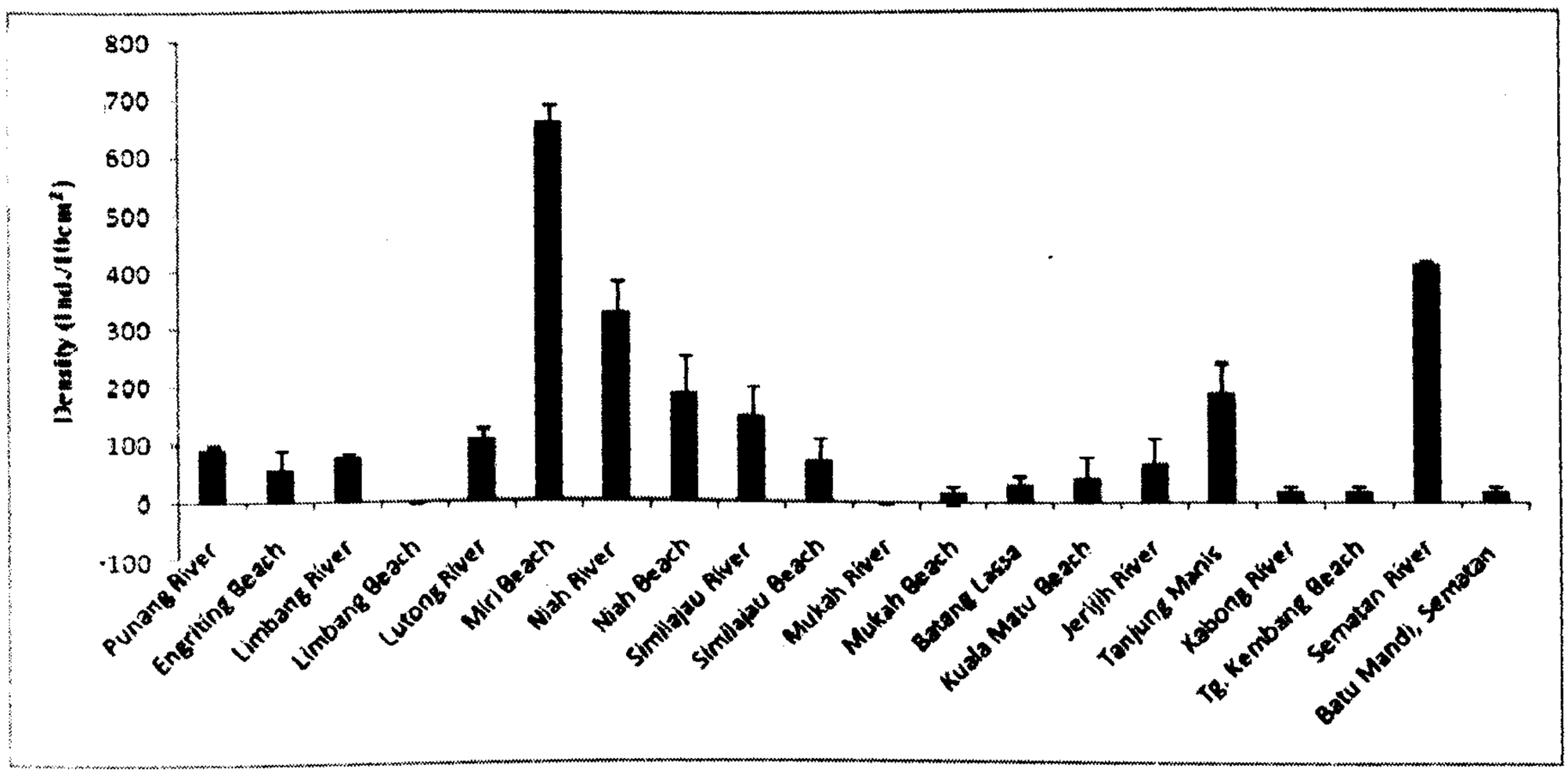

Figure 3.2: Nematode density (ind. /10 cm^2) along the Sarawak coastal waters recorded during the study.

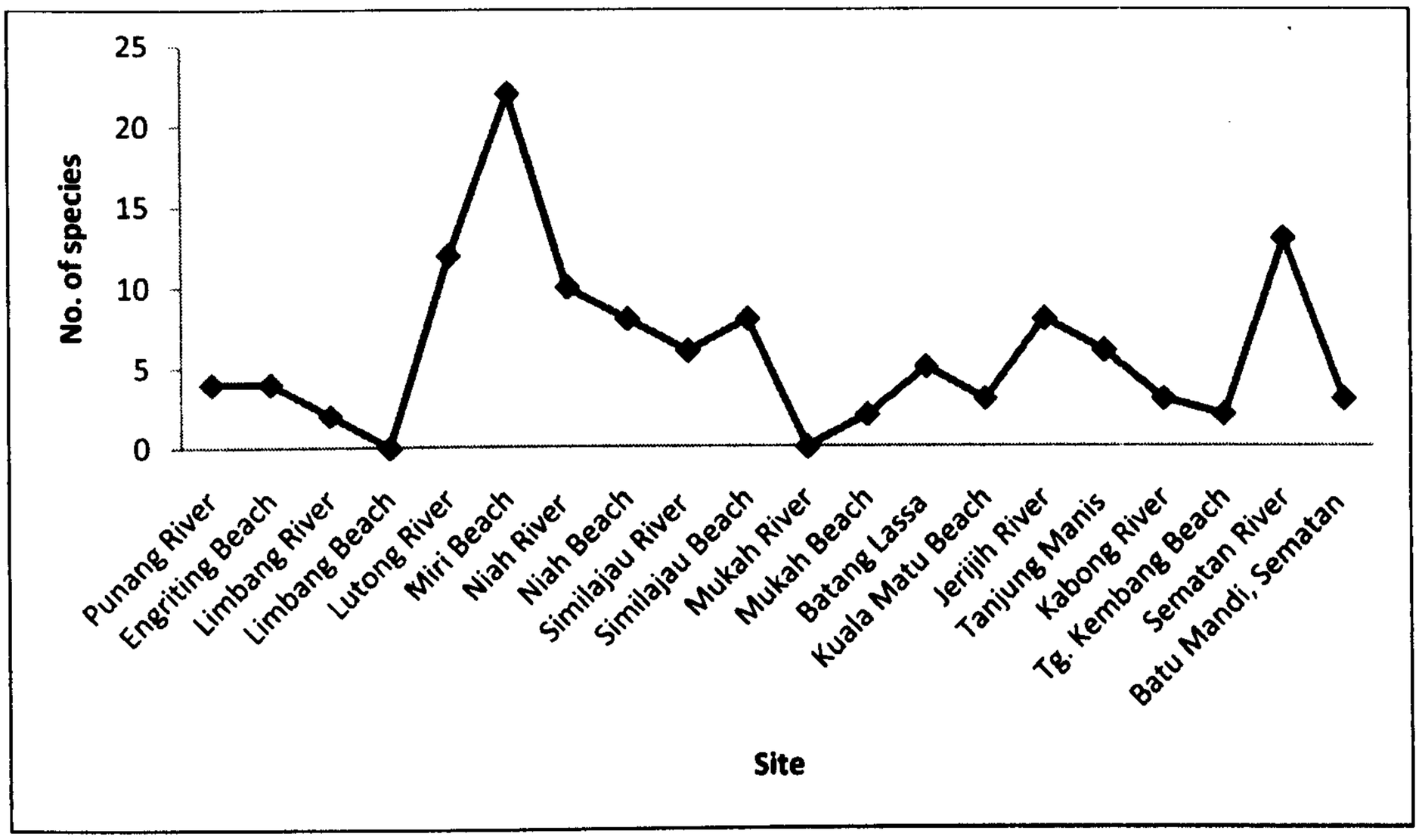

Figure 3.3: Number of nematode species along the Sarawak coastal waters.

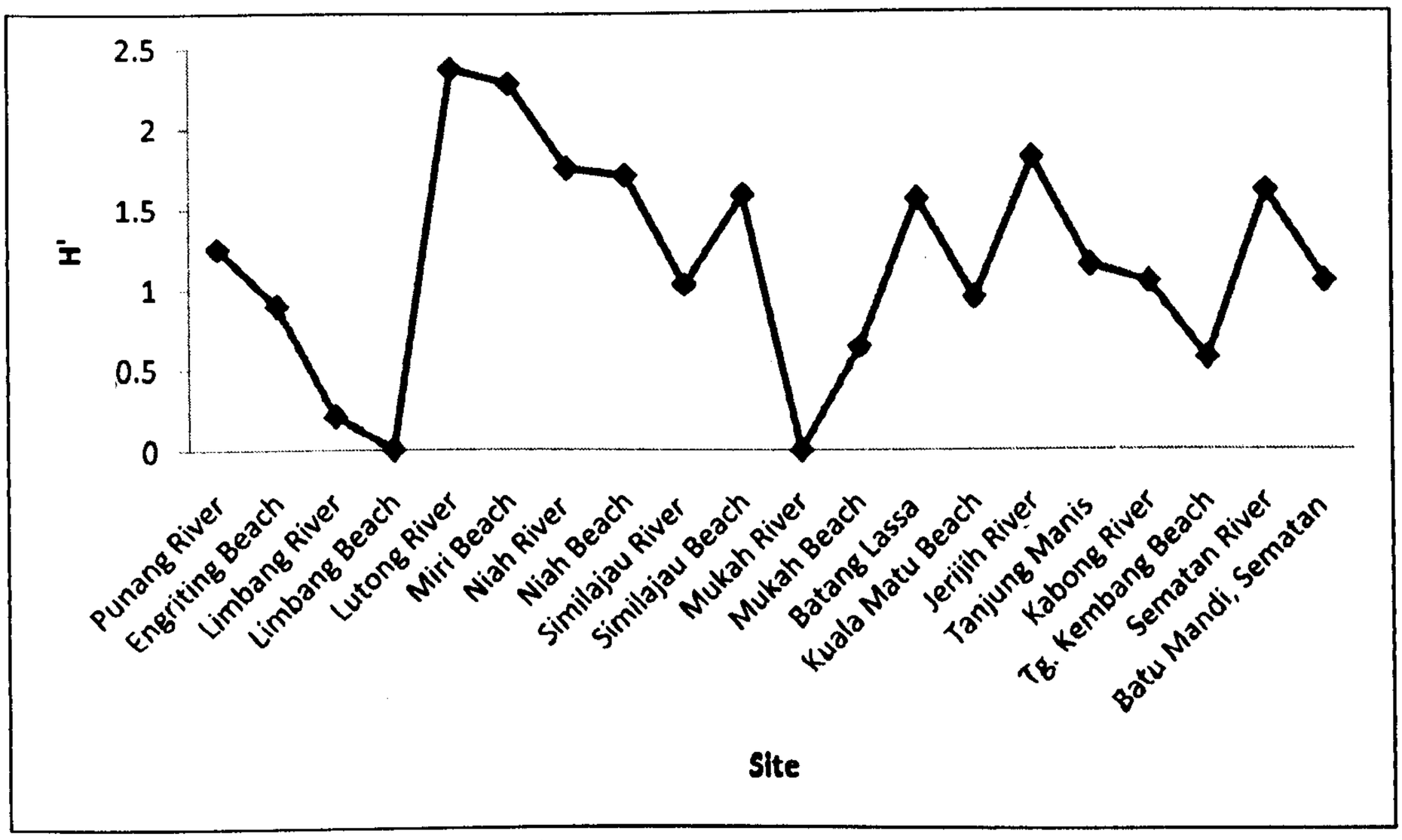

Figure 3.4: Shannon-Weiner species diversity index along the Sarawak coastal waters.

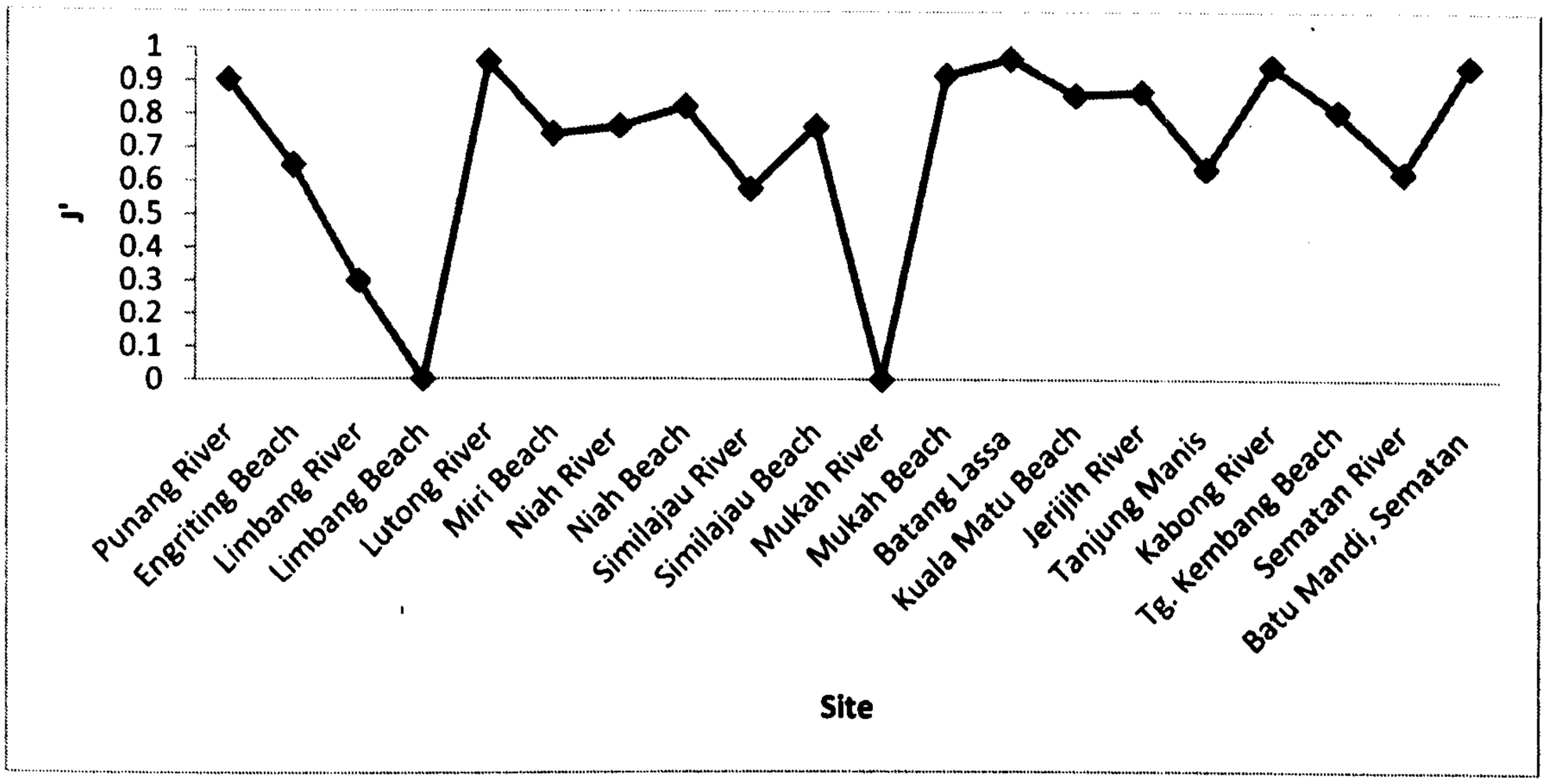

Figure 3.5: Pielou's evenness of the nematode species along the Sarawak coastal waters.

A multi-dimensional scaling (MDS) resemblance from Bray Curtis similarity matrix showed that the sites were clustered into four distinct groups (Figure 3.6). Limbang beach, Mukah River and Kabong River were separated from each other while the other 17 sites were formed into a group. This showed that the 17 sites which were clustered together had similarity either in species density or diversity. Meanwhile the other three separated sites were observed to have extreme low species diversity or density (i.e. site Limbang beach and Mukah River recorded with zero marine nematode). The dendrogram in Figure 3.7 showed on the clustering of the studied sites. At the similarity level of 20 %, 18 groups of sites were formed. This showed on the high dissimilarity percentage in the marine nematode species of each study sites. In a one-way ANOSIM test, the calculated result showed that the abundant of the marine nematode in the coastal study was significantly different (p-value = 0.001) (Appendix B1). BioEnv (Biota and/or Environment Matching) showed a combination of four environmental parameters were positively correlated with the marine nematode species density in the present coastal study. The four parameters were pH, DO, sand and silt

(correlation = 0.311) (Appendix C1). The calculated result demonstrated that the combination of the four parameters was contributing to the distribution pattern of the marine nematode species in Sarawak coastal waters.

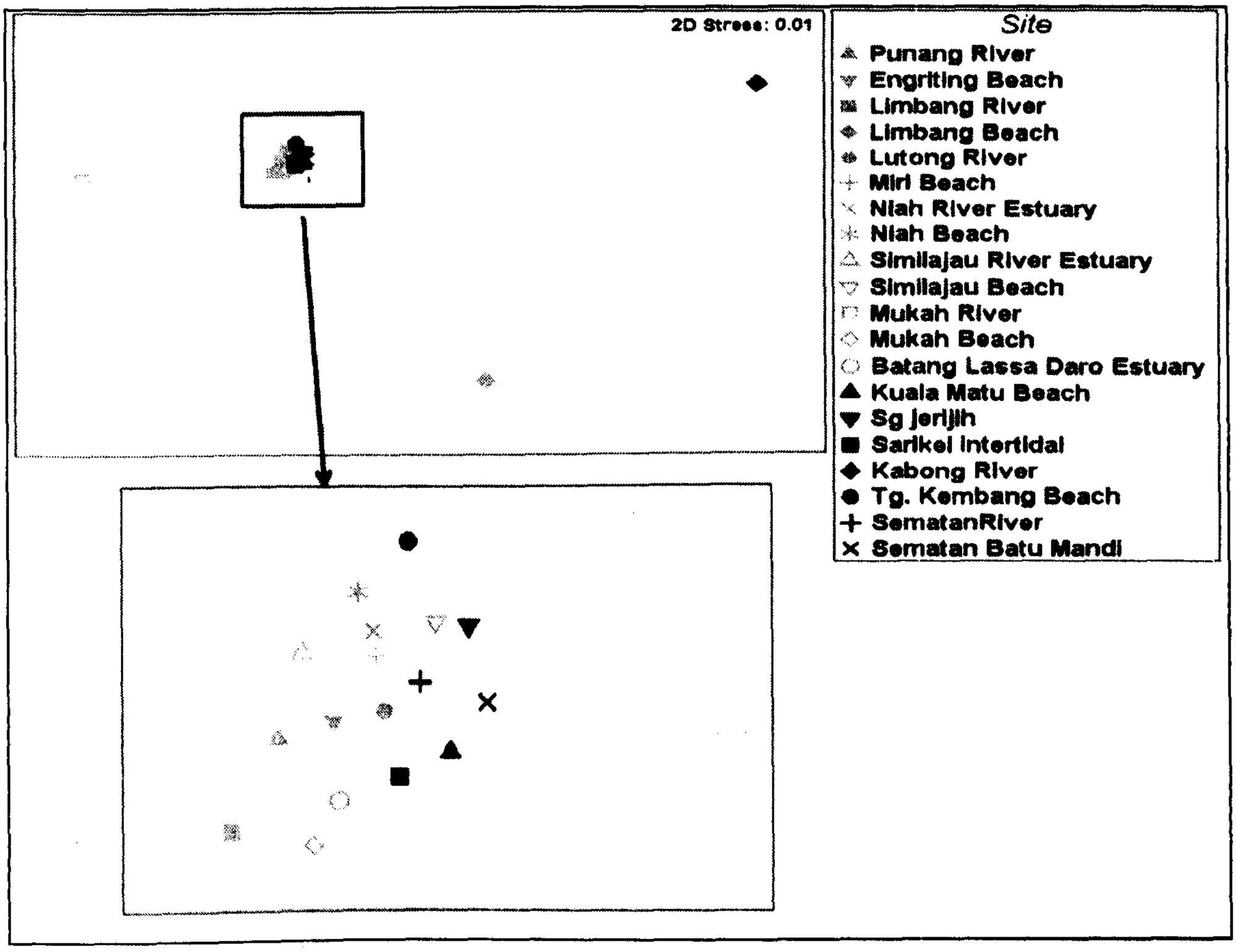

Figure 3.6: Two-dimensional MDS ordination constructed from the mean densities of each nematode species at each of the 20 sites.

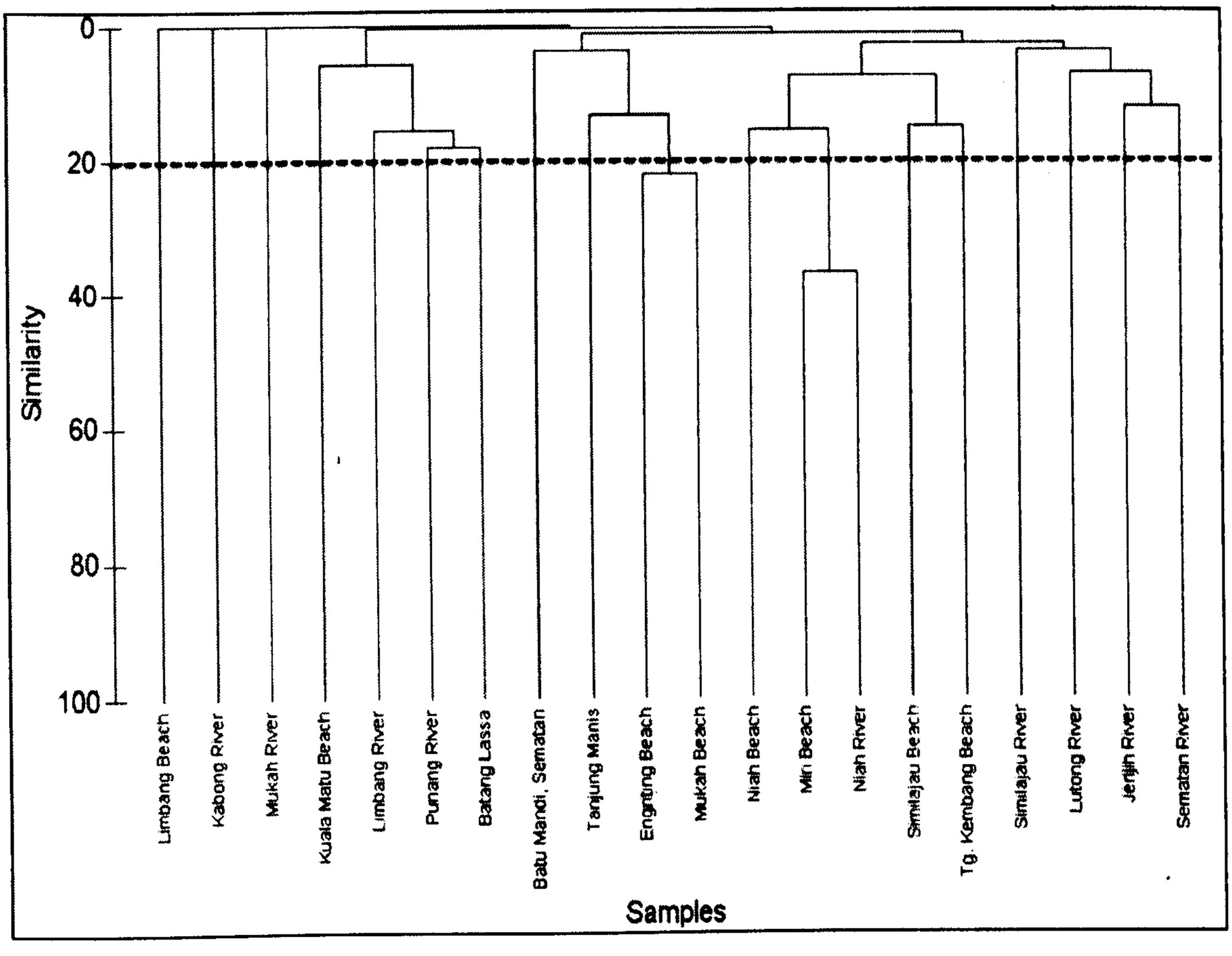

Figure 3.7: Dendrogram produced by cluster analysis showing the percentage of similarity between Sarawak coastal sites.

3.2 Horizontal study of marine nematode at Teluk Awar

3.2.1 Environmental parameters

The physico-chemical and biological parameters are listed in Table 3.3. The one-way ANOVA analyses showed that each physico-chemical parameters within site (salinity, temperature, pH and DO) were significantly different among stations (Appendix A2 and A3). Most of the records on salinity showed the normal seawater (30 PSU and above) except for station 1. Overall, the temperature were recorded to be high (approximately 32 – 34 °C) while lower readings were recorded at station 7 (site B) and sublittoral stations (station 8 and 9). The pH readings of the present study in Teluk Awar were in the range of 8.79-9.71 (alkaline water). The DO readings were recorded to be low (pore water) in all intertidal stations except at station 7. The highest DO was found in the sublittoral stations (station 8 and 9).

One-way ANOSIM on the particle size component once again showed that there was no significant difference between sites (p-value= 0.899) (Appendix B2) but significantly different between stations (p-value= 0.025; R-statistic= 0.349) (Appendix B3). Principal Component Analysis (PCA) for the various particle size fractions showed 99 % of the total variation in the principal component axes 1 and 2 (Figure 3.8). Visually, most of the stations showed a very marked tendency to group together on the PCA plot. Station A3, A5, A6, A9, B3, B4, B5 and B9 were dominated by the particle size fraction of 63 μm (very fine sand). Station B2, A2 and A8 were marked comprising greater silt fractions while station A1, B1 and A7 were reacorded with higher percentage of 125 μm size particle fractions (fine sand). Station A2, A4, A8, B6, B7 and B8 showed a dominancy of two particle fractions (63 μm and

silt), the higher percentage of contributions were based on the distance of the site/station towards 63 μm or silt label.

TOM showed no significant difference within site B (p value > 0.05) accepting the null hypothesis that there was no significant difference. TOM showed significant diffence in site A where the highest value was recorded in the sediment of station 2. Lowest organic matter concentration was detected in the samples from station 9 (subtidal station). The chl *a* concentration was detected to be significantly different in site A (p value < 0.05) (Appendix A2). Chl *a* concentration in site B showed no significant difference (Appendix A3). One-way ANOSIM showed significant difference in environmental variables within each studied site A and B (p-value= 0.001; R- statistic: 0.344) (Appendix B5). A second comparison was carried out between site A and B showed no significant difference (p-value= 0.869; R-statistic= -0.048) (Appendix B4).

Table 3.3: Mean of abiotic and biotic parameters associated with the standard deviation for both sites in Teluk Awar.

Station	Site	Environment Physico-chemical Parameters (abiotic) and biotic factors								
		Salinity	Temperature	pH	DO	Sand %	Silt %	Clay %	Chl *a*	TOM
1	A	14.00±0.00	29.95±0.13	8.79±0.08	2.00±0.16	97.60	1.60	0.80	0.29±0.12	0.94±0.01
	B	11.00±0.00	32.97±0.01	9.00±0.21	0.80±0.07	92.30	4.10	3.60	0.17±0.00	1.14±0.02
2	A	30.00±0.00	32.79±0.10	9.45±0.13	1.49±0.09	28.30	62.20	9.40	1.73±0.38	2.26±0.23
	B	36.00±0.00	35.60±0.00	9.60±0.01	0.40±0.01	5.30	88.00	6.80	0.87±0.44	1.42±0.12
3	A	34.00±0.00	32.74±0.03	9.71±0.01	1.24±0.12	91.70	6.90	1.40	1.01±0.44	1.80±0.02
	B	35.00±0.00	35.14±0.08	9.50±0.01	0.50±0.02	84.70	13.40	1.90	1.52±1.13	1.54±0.10
4	A	36.00±0.00	33.07±0.13	9.55±0.04	1.08±0.04	46.10	49.10	4.80	0.56±0.11	1.58±0.05
	B	39.00±0.00	33.77±0.06	8.90±0.00	0.40±0.09	92.60	6.90	0.50	0.20±0.20	1.48±0.09
5	A	34.00±0.00	33.71±0.33	9.25±0.11	1.17±0.23	82.90	16.10	1.00	0.73±0.32	1.57±0.02
	B	37.00±0.00	35.03±0.05	9.40±0.04	0.80±0.02	77.90	19.40	2.70	0.10±0.05	1.67±0.06
6	A	34.00±0.00	33.78±0.32	9.40±0.12	1.00±0.14	84.20	13.90	1.90	1.05±0.12	1.34±0.16
	B	38.50±0.71	34.78±0.08	9.50±0.01	0.40±0.00	44.20	51.10	4.70	0.47±0.30	1.89±0.12
7	A	36.50±0.71	33.93±0.03	9.41±0.04	3.55±0.00	84.60	14.50	0.90	0.82±0.12	1.38±0.06
	B	37.00±0.00	33.12±0.02	9.40±0.02	3.40±0.00	54.90	40.90	4.30	0.11±0.03	1.26±0.07
8	A	34.00±0.00	29.51±0.28	9.07±0.25	3.70±0.03	24.20	60.20	15.60	3.87 ±1.94	1.79±0.23
	B	32.00±0.00	29.65±0.00	9.00±0.02	3.50±0.00	60.30	35.70	4.00	0.06±0.03	1.12±0.18
9	A	35.00±0.00	29.74±0.01	9.39±0.03	3.83±0.01	83.50	15.90	0.60	0.25±0.28	0.87±0.05
	B	34.00±0.00	29.65±0.00	9.20±0.01	3.80±0.00	73.50	24.20	2.30	0.07±0.01	1.41±0.59

* DO – dissolved oxygen; Chl *a* – chlorophyll *a*; TOM – total organic matter

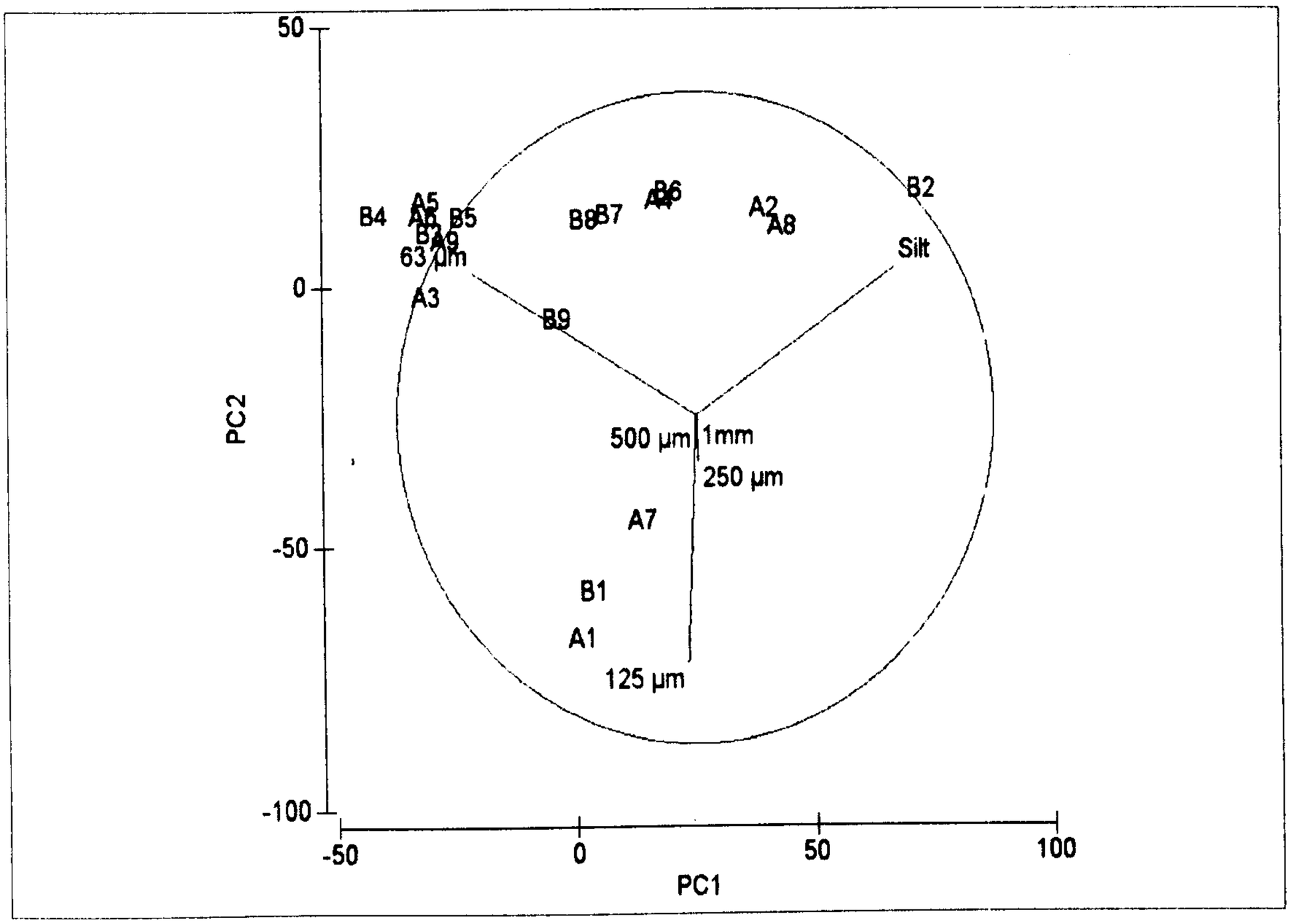

Figure 3.8: Principle component analysis plot derived from the mean percentage contribution of the various grain-size fractions to the sediment samples obtained from each site and stations. Principle component axes 1 and 2 accounted for 99.0% of the total variation present.

3.2.2 Densities, number of species and species distribution among 2 sites

The results of the nematode density were shown in Figure 3.9. Generally the density of the nematode in site A did not fluctuate dramatically in the intertidal area but decreased spontaneously in the subtidal samples. The highest densities of nematode were recorded in the mid tide level of site A (station 4). However, the nematode densities in site B were totally different compared to site A. It irregularly fluctuated along transect from high tide to subtidal area. The lowest marine nematode densities were recorded in station 4, 6, 8 and 9 for for site

B while the highest nematode density in site B was recorded in station 1 followed by station 5 and 7.

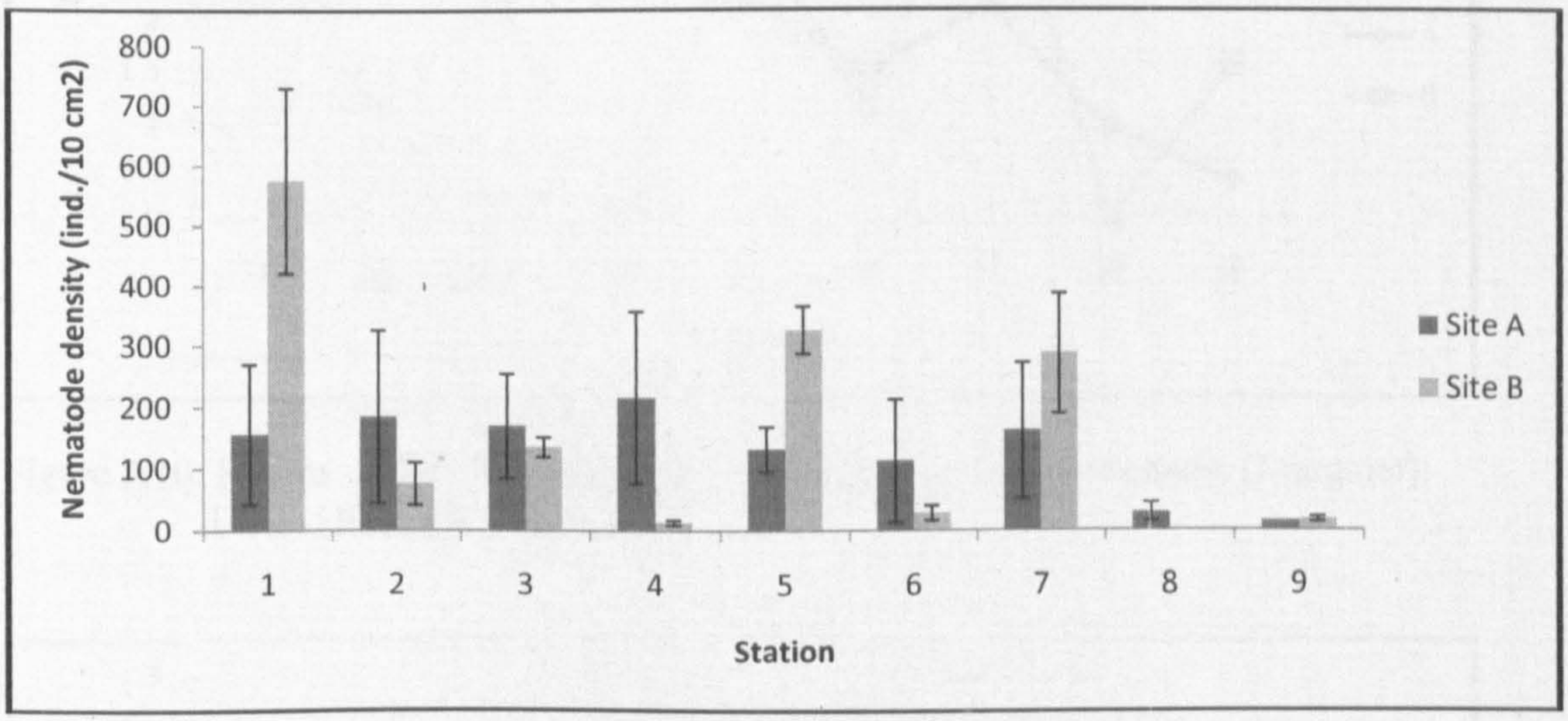

Figure 3.9: Nematode density in each studied stations (mean ± standard deviation).

The results of Univariate Diversity Indices on site A and B were plotted in Figure 3.10, 3.11 and 3.12. Site A showed a tendency of increasing in species richness from station 1 to the mid tide level (station 3) but started to decrease after that until station 6. An increasing of species richness was recorded at the low tide station (station 7) but decreased in the subtidal stations (station 8 and 9). Site B did not showed a systematic trend to indicate the species richness as it fluctuated along the studied transect. Shannon-Weiner species diversity indices of station 4, 6, 7 8 and 9 (site A) were lower than 2.0. Lower diversity indices (lower than 2.0) in site B were recorded in station 2, 3 4, 6, 7, 8 and 9. Pielou's evenness showed a dramatically fluctuation in site B while site A consistently showed on small changes within each stations.

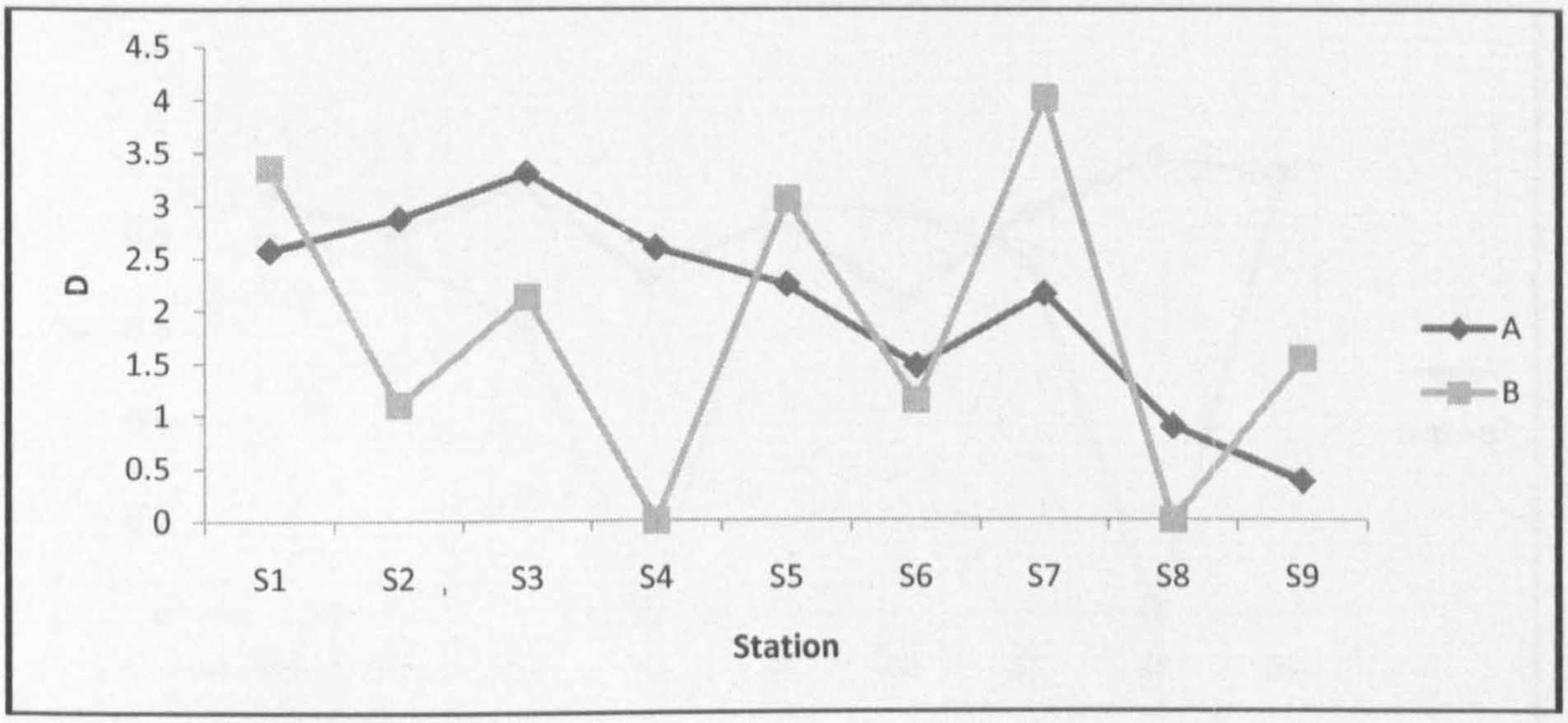

Figure 3.10: Results of the Univariate Diversity Indices on species richness (Margalef): D=(S-1)/Log (N).

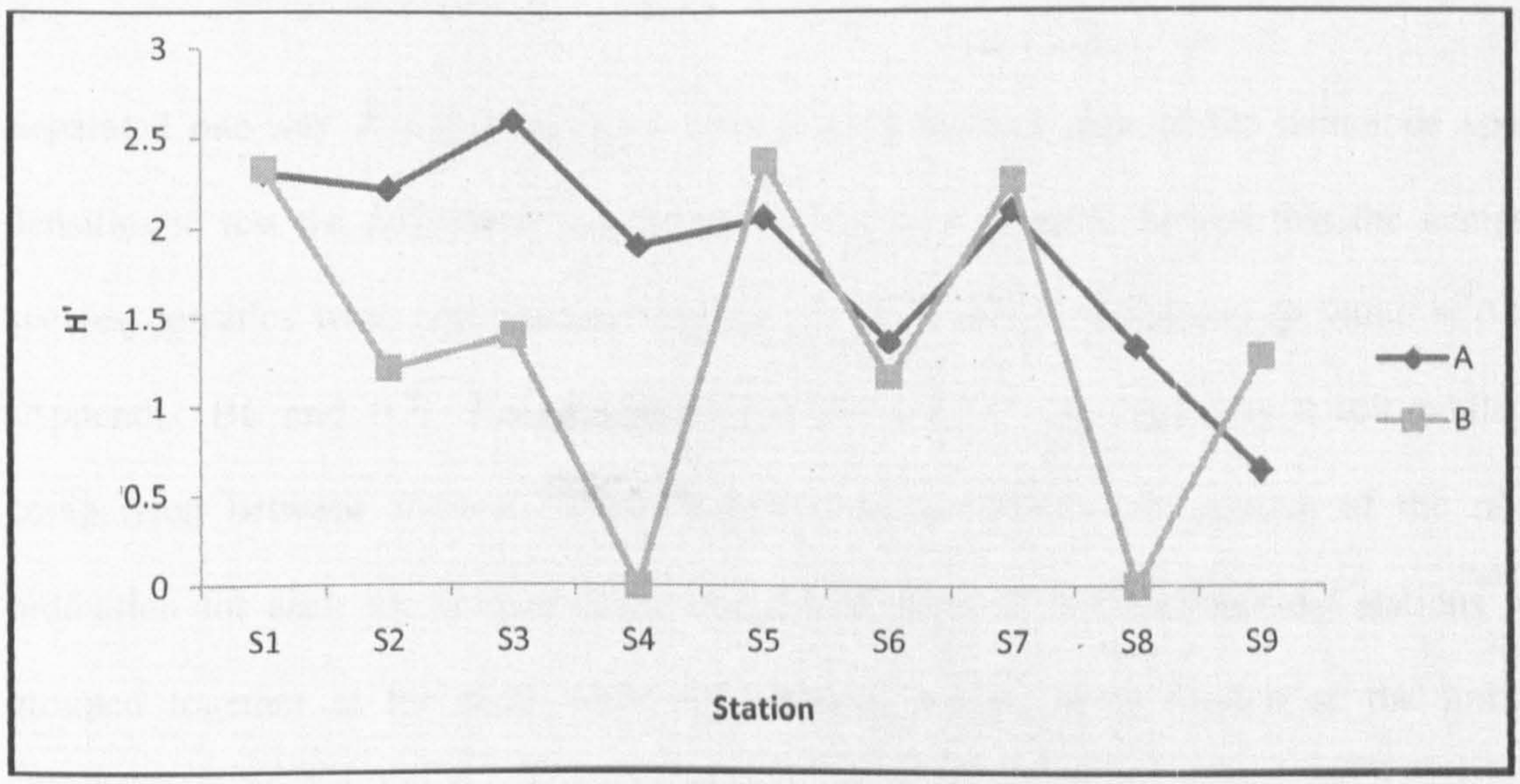

Figure 3.11: Results of the Univariate Diversity Indices on Shannon-Weiner species diversity index (H').

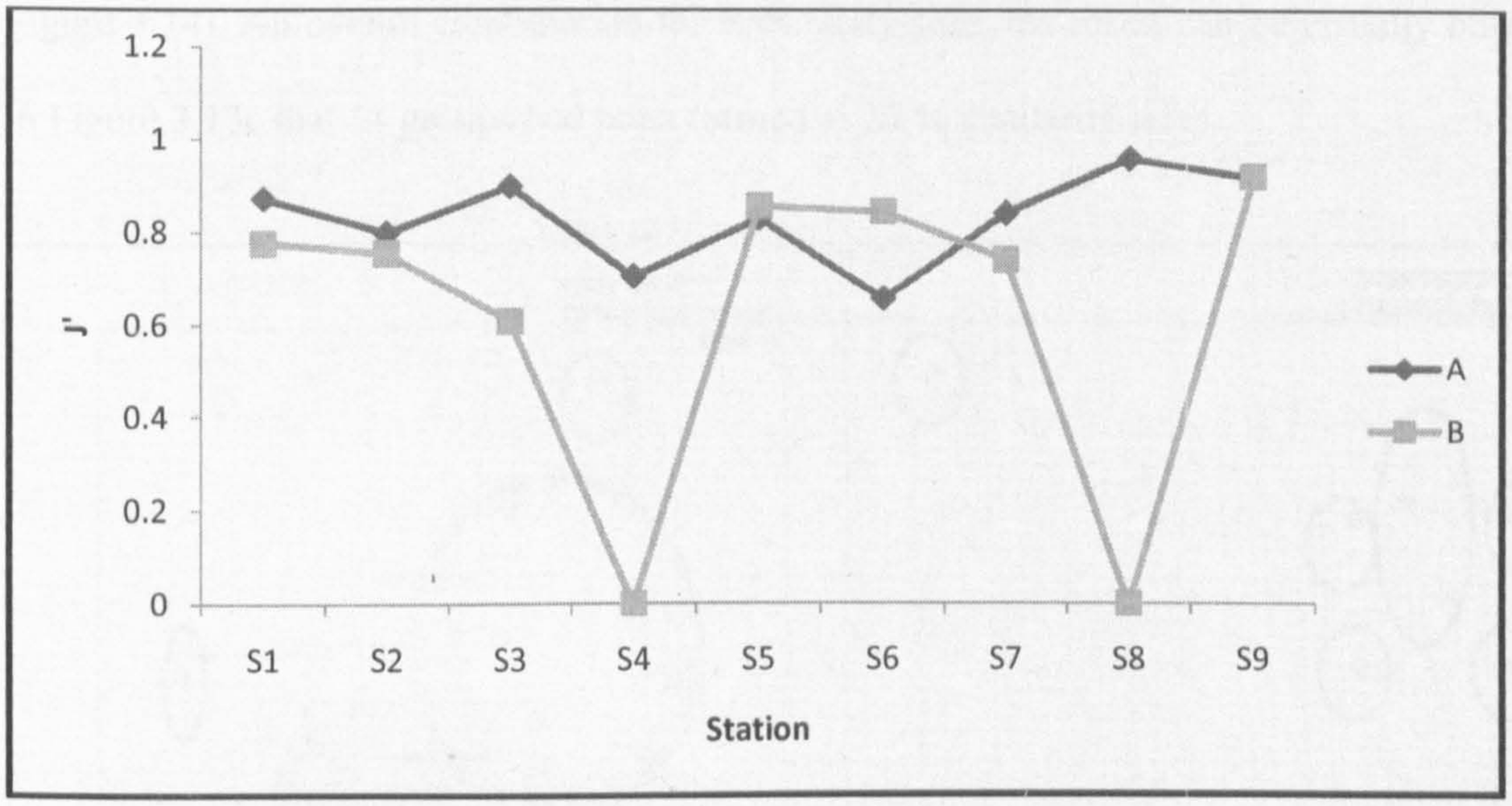

Figure 3.12: Results of the Univariate Diversity Indices on Pielou's evenness: J'=H'/ Log_2 (S).

Separated one-way ANOSIM was conducted using the raw data of the nematode species densities to test the difference within and among sites. Results showed that the nematode species densities were significantly different in both sites and stations (p value = 0.001) (Appendix B6 and B7). The R-statistic for the test among sites was 0.169 while the comparison between stations showed higher reading (0.761). The results of the nMDS ordination for each site (Figure 3.13a and 3.13b) showed that the intertidal stations were grouped together at the right while the subtidal stations were located at the left. 2D configuration was good enough to represent each of the study sites with the stress level of 0.08 and zero. A third nMDS was conducted on the mean densities for both sites showed that most of the stations in both sites were clustered together except for B8 and B9 with a 2D configuration of stress level 0.01. At the similarity level of 20 %, the marine nematode species densities in the study site A were grouped into five groups as shown in the circle of Figure 3.13a (with the aid of Figure 3.14). The similarity level of site B was lower compared to site A as seven groups had been formed at the similarity level of 20 % (with the aid of

Figure 3.14). An overall combination for both study sites, the result can be visually observed in Figure 3.13c that 11 groups had been formed at 20 % similarity level.

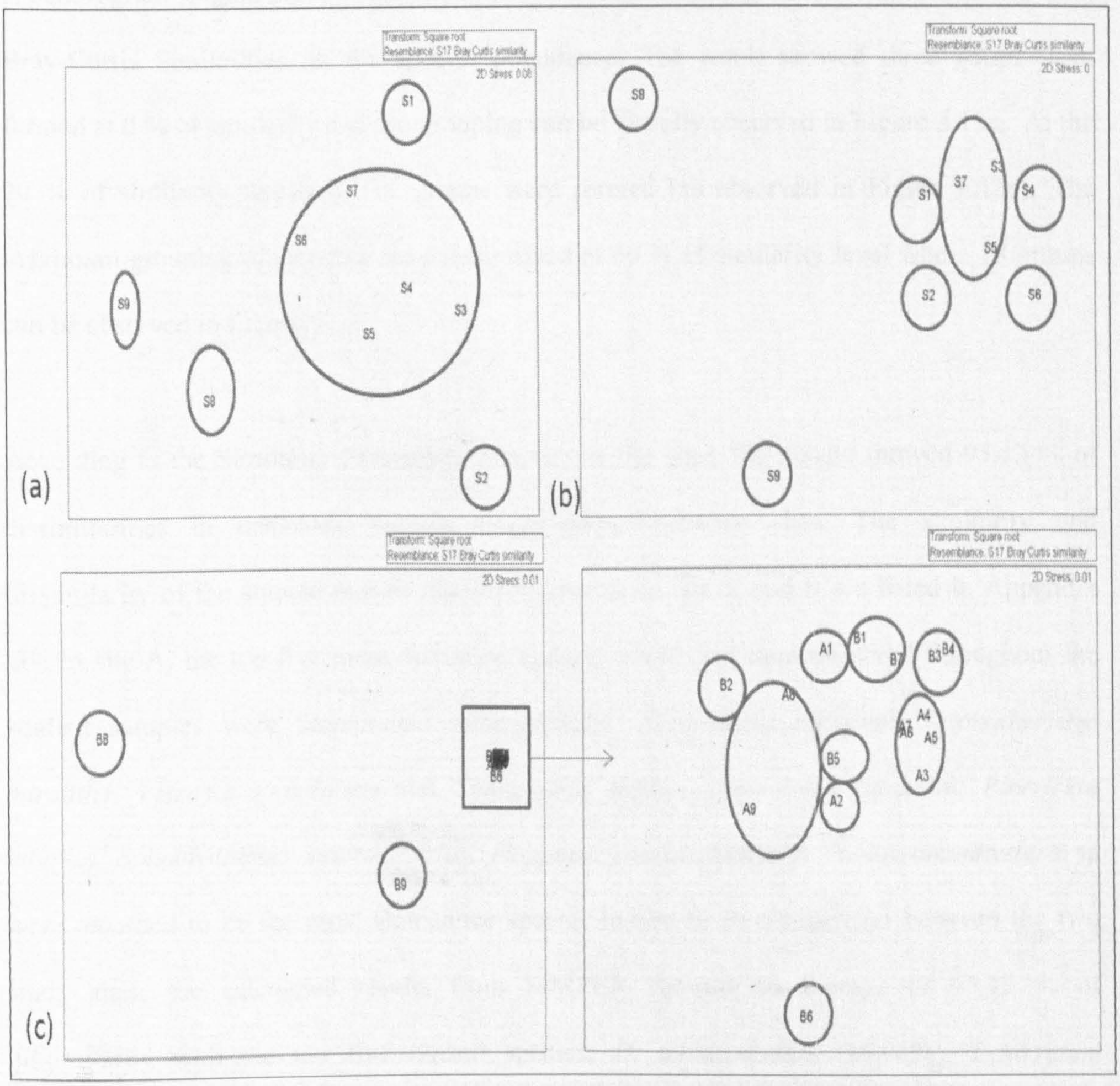

Figure 3.13: Two-dimensional MDS ordination of the similarity matrix constructed from the mean densities of each nematode species at (a) site A, (b) site B and (c) site A+B.

3.2.3 Comparison of nematode species compositions among sites and stations

A dendrogram (Figure 3.14) of the two sites were plotted using group average clustering from Bray-Curtis Similarities on the species abundance. The result showed three goups were formed at 0 % of similarity and the grouping can be visually observed in Figure 3.13c. At the 20 % of similarity threshold, 11 groups were formed (as observed in Figure 3.13c). The maximum grouping of samples were determined at 40 % of similarity level where 18 groups can be observed in Figure 3.14.

According to the Similarity Percentage test among the sites, the results showed 95.12 % of dissimilarities in nematode species compositions between sites. The similarity and dissimilarity of the studied marine nematode species in site A and B are listed in Appendix D1. In site A, the top five most dominant species which had been observed throughout the studied samples were *Daptonema tenuispiculum, Daptonema hirsutum, Trichotheristus mirabilis, Viscosia stenolaima* and *Daptonema setifer. Daptonema hirsutum, Pierrickia vitielloi, Sphaerolaimus macrocirculus, Hopperia massiliensis* and *Thalassomonhystera* sp were recorded to be the most abundance species in site B. In comparison between the two study sites, the calculated results from SIMPER showed an average of 95.12 % of dissimilarity with the top five ranked species: *D. tenuispiculum* (10.91%), *D.hirsutum* (9.77%), *T. mirabilis* (3.39%), *S. macrocirculus* (3.20%) and *V. stenolaima* (2.56%) (Appendix D1).

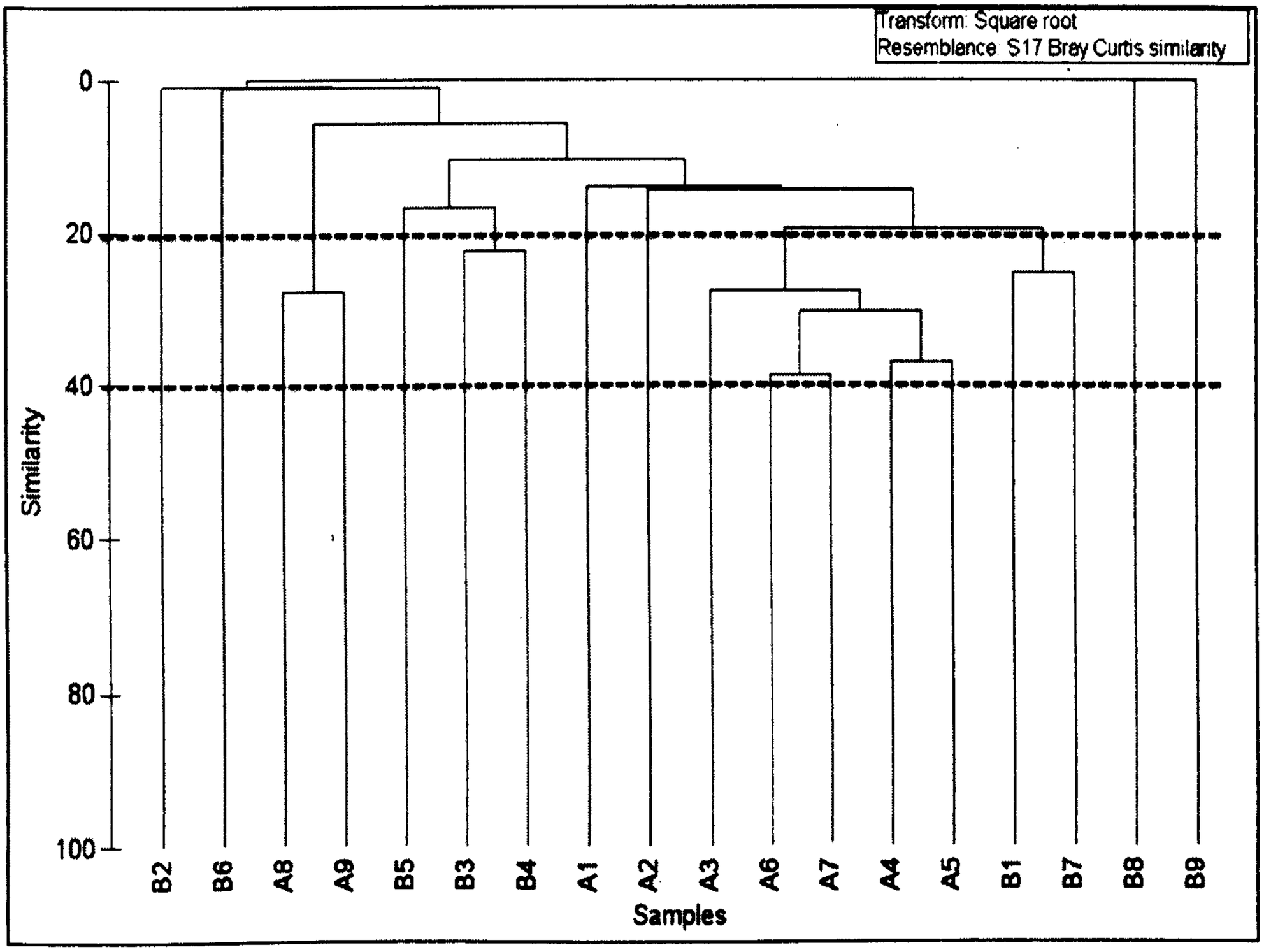

Figure 3.14: Dendrogram produced by Cluster Analysis for the horizontal study in Teluk Awar.

3.2.4 Relationship between nematode assemblages and environmental variables

The results in the one-way ANOSIM showed no significant difference in the environmental variables between site A and site B. However, a second one-way ANOSIM showed significant difference within both study site A and B. Draftsman plot was conducted on the environmental parameters for both study sites to determine the skewness of the data (Figure 3.15 and 3.16). The result showed that environmental parameters (clay percentage, DO and chl *a*) were left-skewed. A Log transformation was conducted to reduce the skewness.

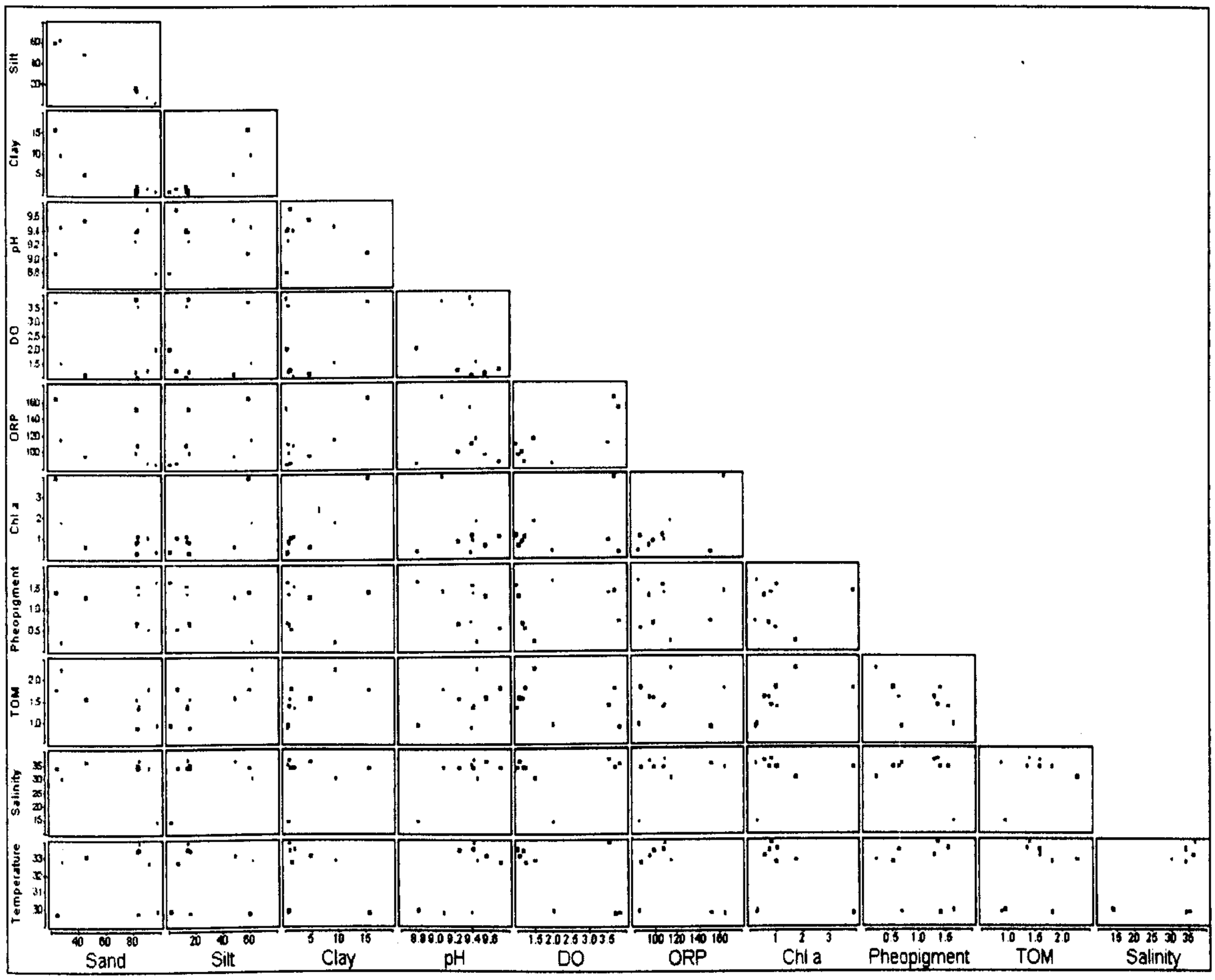

Figure 3.15: Draftsman plot for site A environment parameters.

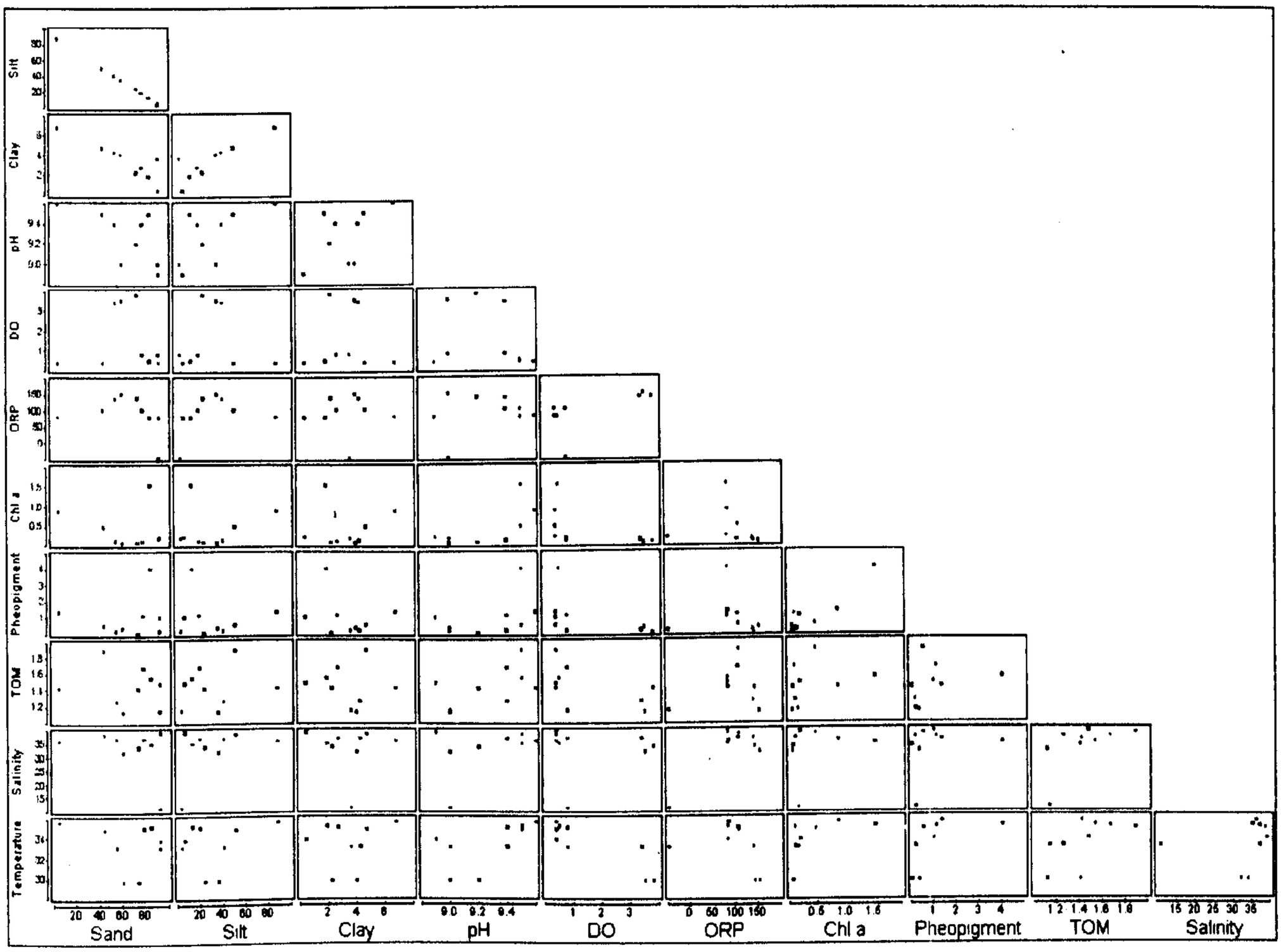

Figure 3.16: Draftsman plot for site B environment parameters.

BioEnv (Biota and/or Environment Matching) tests were carried out to determine the relationship between nematode assemblages and environment variables within each site using Spearman correlation subjected to the Euclidean distance matrix. The BioEnv showed that the best pairing of environmental variables that contributed to the marine nematode species densities in site A of Teluk Awar was TOM, salinity and temperature with the correlation value of 0.647 (Appendix C2). The high correlation reading suggested that the nematode community structure of site A in Teluk Awar was mostly influenced by the three variables. With an addition of another environmental variable (DO), the correlation still maintained to be high 0.643. For site B, the result of the BioEnv showed that the best pairing of the

environment variables which influenced the nematode community structure of site B was particle size fraction (clay), TOM and temperature (correlation= 0.604) (Appendix C3).

3.2.5 Analysis of the functional feeding group

One-way ANOSIMs for both study sites accepting the null hypothesis that there was no significant difference in the functional feeding group (FFG) for nematode assemblages (marine species) within and between sites (p-value= 0.15; 0.442 latter) (Appendix B8 and B9). When the functional feeding groups of the nematode assemblages in each stations and sites were subjected to a PCA analysis, a two-dimensional plot encompassed 78.8% of the total variation in the data was produced (Figure 3.17). The plot showed that only station B2 was dominated by the FFG of 2A (50 % out of total species discovered in the collected samples). The results of the present study show that the marine nematode assemblages in Teluk Awar were mostly dominated by the FFG of 1B and 2B except for station B2, A9 and B9. The subtidal station A9 and B9 were dominated by the FFG of 1A. Appendix E2 shows on the functional feeding group and the mean density percentage contribution of each nematode species in Teluk Awar (Site A and B).

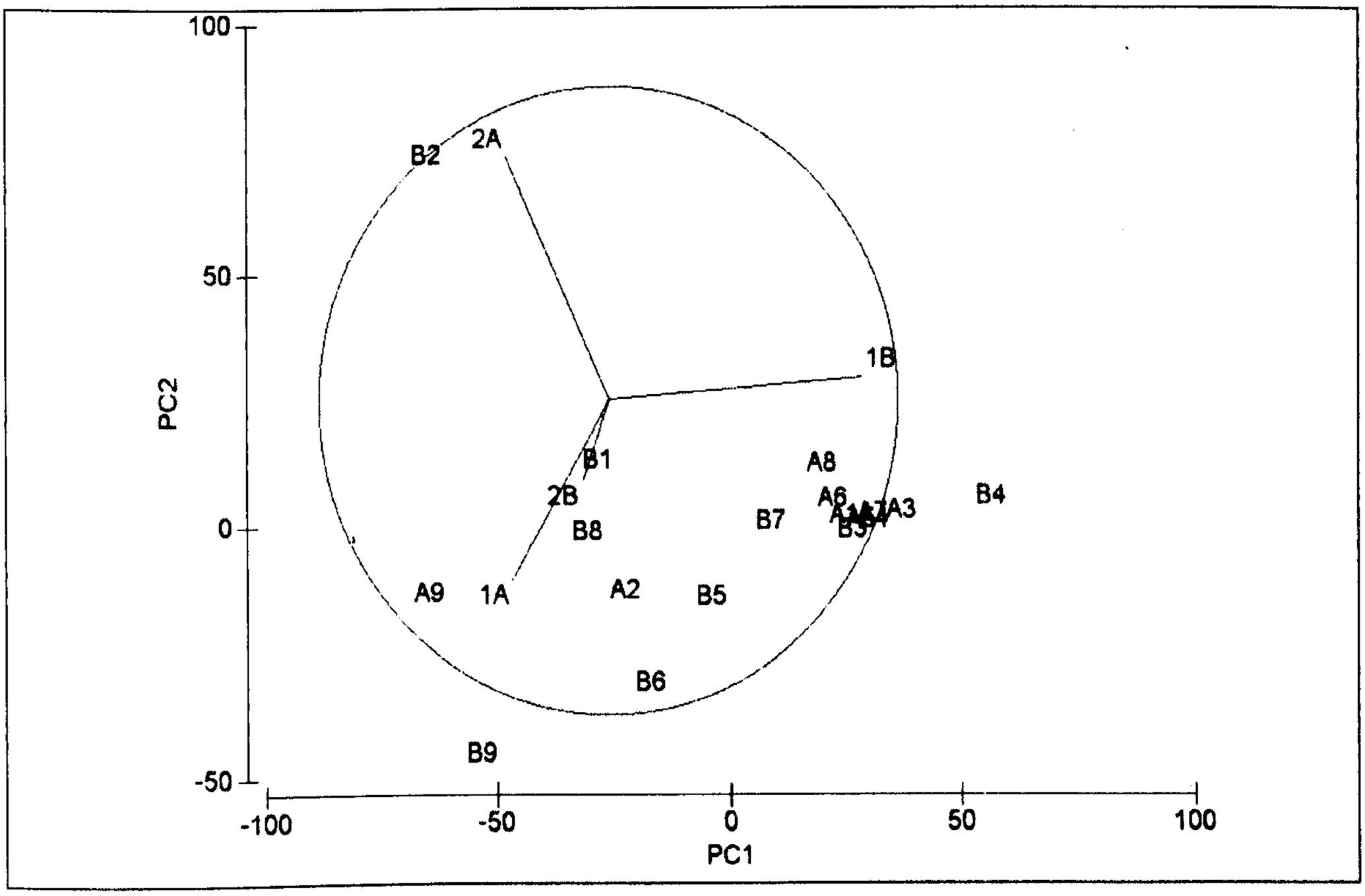

Figure 3.17: Principle component analysis plot derived from the mean percentage contribution of the functional feeding group (FFG) of nematode species from each site and stations.Principle component axes 1 and 2 accounted for 78.8% of the total variation present.

3.3 Vertical Profile of Marine Nematode at Teluk Awar

3.3.1 Environmental parameters

A vertical profiling study was conducted to determine the vertical distribution pattern of marine nematode community structure in Teluk Awar. Station 8 and 9 for both site A and B in the horizontal study were excluded (subtidal samples). The detailed measurements of mean environmental variables from the sampling sites are given in Table 3.3. After excluding subtidal site 8 and 9 for both transects, certain environmental variables showed significant difference within each study site compared to the results in Section 3.2. The one-way ANOVA showed that the salinity, temperature, DO, pH, and TOM were significantly different within both study sites except for chl *a* which showed no significant difference in site B (Appendix A4 and A5).

Beside the *in situ* parameters, an observation on the changes of sediment colours in different depth had been conducted during the field sampling. The marine nematodes were mostly found in the upper 5 cm layer (90 - 100 %) in both sites. In most of the observed stations within site A, the yellow layer of the sediment changed to gray-dark layer at the depth of 8-11 cm. Meanwhile, the changes of the sediment colour from yellow to gray-dark layer were recorded at the depth of 2 - 6 cm in site B (except for station 2 where the changes occurred at the depth of 0.5 mm).

A one-way ANOSIM was conducted on the site and stations after the exclusion of subtidal stations. The results were paralleled with that in Section 3.2.1where environment variables

had no significant difference among sites (p-value= 0.306; R-statistic = 0.033) but significantly different within sites (p-value= 0.013; R-statistic = 0.371) (Appendix B10 and B11). Result on the particle size analysis was explained in Section 3.2.1 using the Principal Component Analysis (PCA) with the aid of Figure 3.8.

3.3.2 Densities, number of species and species distribution among two sites

Result in Figure 3.18 showed on the marine nematode densities of different depth in the study area. A significant difference was recorded between the two study sites where no nematode was recorded below the depth of 5 cm in site B. Nematodes were detected at the depth of 6 - 15 cm in certain stations of site A. The highest density was recorded in station B1 followed by station B5 and B7 (upper 5 cm depth). Nematode densities in site A did not show a distinct fluctuation but present in different depth layers. However, most of the nematodes were recorded at 0 - 5 cm depth.

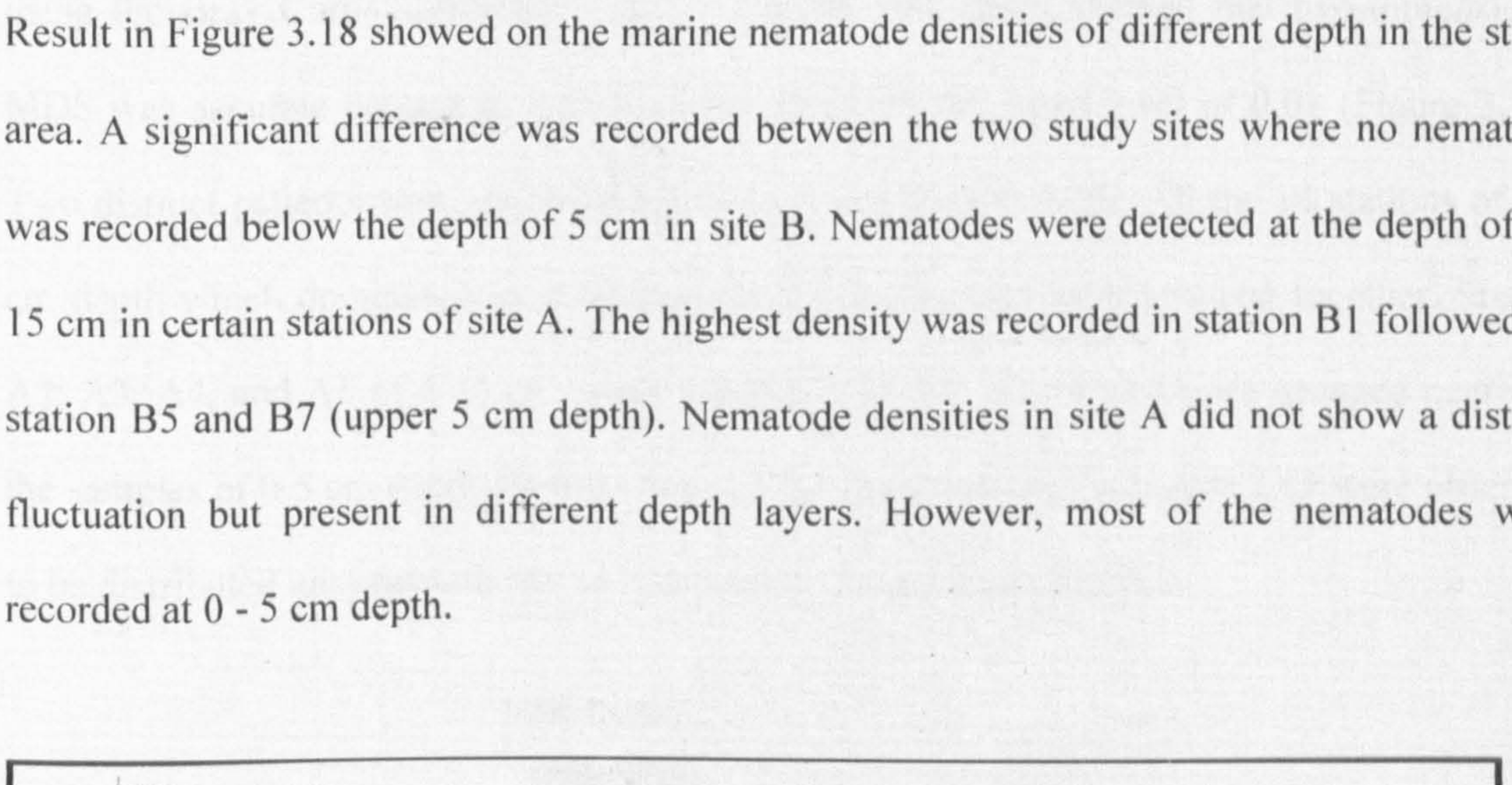

Figure 3.18: Distribution of nematode density at different sediment depth.

A separated one-way ANOSIM had been conducted to determine the difference of marine nematodes. Results showed that the nematode species abundance were different between sites (p-value= 0.005; R-statistic= 0.031) (Appendix B12). The result yet matched with the finding in Section 3.2.2. A two-way ANOSIM was conducted on the station and depth factors showed significant difference in nematode species abundance not only between stations (p-value = 0.001; R-statistic = 0.121) (Appendix B13) but also depth (p-value = 0.001; R-statistic=0.45) (Appendix B13). Mean densities of the nematode species were used to conduct the nMDS using the Bray Curtis similarity matrix on depth. The result showed that two-dimensional MDS was accurate enough to represent the data with the stress level of 0.01 (Figure 3.19). Two distinct patterns were observed based on depth (Figure 3.19). All the 14 stations of 0-5 cm depth which dominated by intensive nematode densities were grouped together. Station A2, A3, A4, and A5 of 6-10 cm depth together with A2 (11-15 cm) were grouped nearer to the samples of 0-5 cm depth. Besides that, all the others stations in Figure 3.19 were observed to be distributed unsystematically as zero nematode had been recorded.

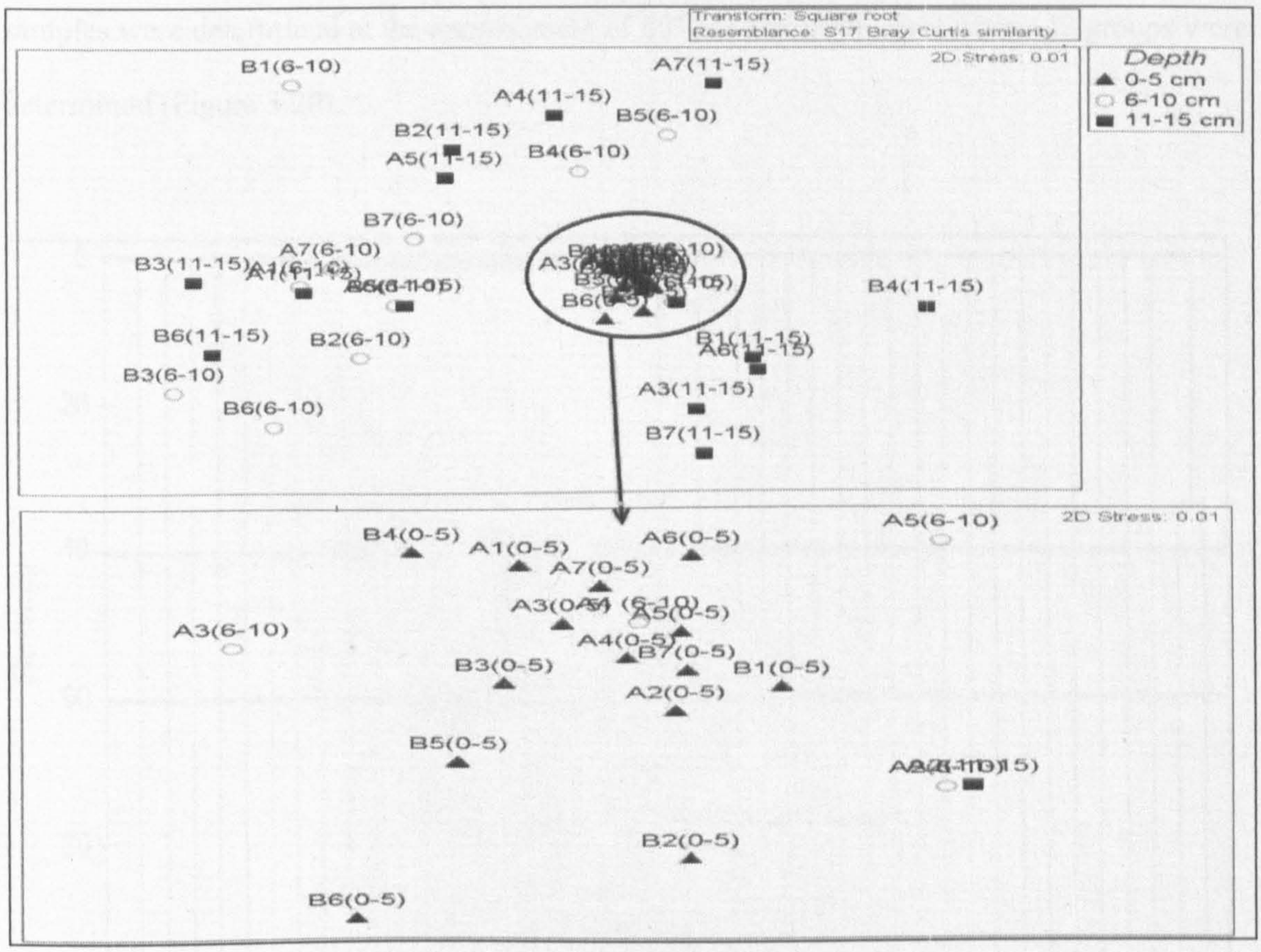

Figure 3.19: Two-dimensional MDS ordination of the similarity matrix constructed from the mean densities of each nematode species according to depth with the stress level of 0.01.

3.3.3 Comparison of nematode species compositions among sites and stations

The combination of the hierarchical clustering and ordination analyses was used to check the adequacy and mutual consistency of both representations. Figure 3.20 shows on the dendrogram from the cluster analysis of the Teluk Awar using the marine nematode data on the sediment depth subjected to the Bray Curtis similarity matrix. The result showed that 23 groups were formed at the level of 0 % of similarities. The circled area (Figure 3.19) was categorized as a group whiles the others that scattered around representing the other 22 At the 40% of similarity threshold, 38 groups were formed. The maximum groupings of

samples were determined at the approximate of 60% of similarity level where 42 groups were determined (Figure 3.20).

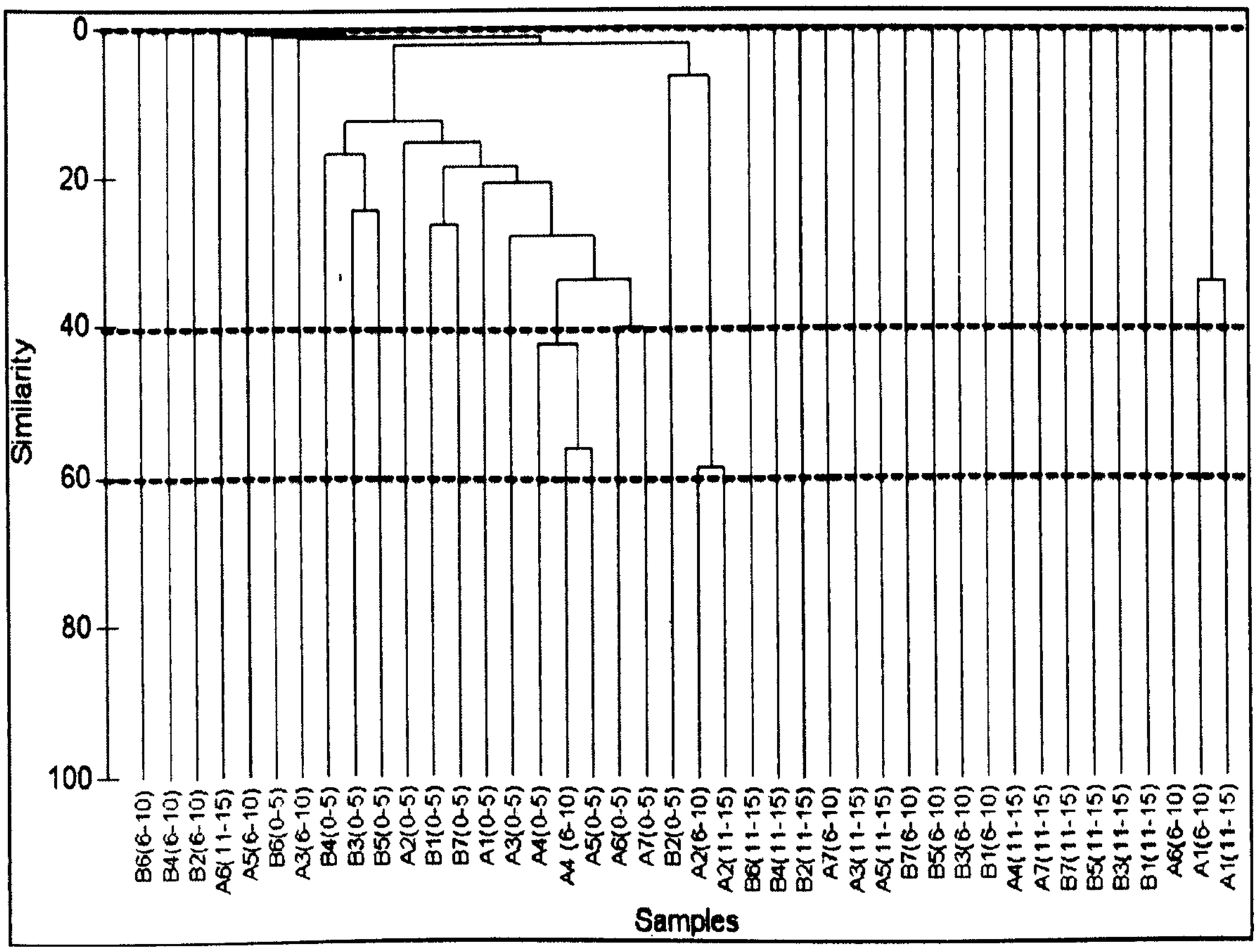

Figure 3.20: Dendrogram of the 7 stations for both site A and B across depths using group average clustering from Bray Curtis similarities matrix on square-root transformed abundances.

In a one-way crossed analysis of SIMPER, the result of the species similarity and dissimilarity was determined (Table 3.4). However, a two-way crossed analysis of SIMPER had been conducted to determine the species similarity and dissimilarity in the vertical profiling study. The nematode species together with the average similarity are shown in Table 3.4. The test was conducted based on the combination of nematode species in site A and B

recorded in the same stations across all depths (eventhough zero nematode was rocorded in the depth after 5 cm in site B) for comparison.

Table 3.4: Species similarity of stations across all depth groups of SIMPER analysis.

Station	Nematode species	Average similariy	Depth (cm)	Nematode species	Average similariy
1	*Daptonema tenuispiculum*	1.72	0 – 5	*Daptonema hirsutum*	10.81
2	*Parodontophora pacifica*	2.34		*Daptonema tenuispiculum*	
3	*Daptonema hirsutum*	7.34	6 - 10	-	-
4	*Daptonema hirsutum*	8.55	11 - 15	-	-
5	*Daptonema hirsutum*	3.09			
6	N/A	0.00			
7	*Daptonema hirsutum*	11.23			
	Daptonema tenuispiculum				

Detailed on the list of species, functional feeding groups, similarity and dissimilarity percentage of contribution are listed in Table 3.5, Appendix E3 and Appendix E4. Result of the SIMPER analysis on depth across all stations showed average similarity and dissimilarity of selected nematode species (Table 3.4 and Table 3.5). At the depth of 0-5 cm, the recorded species were *D. hirstum* and *D. tenuispiculum* with the average similarity of 10.81 % (Table 3.4). Zero similarity was rocorded in both 6-10 cm and 11-15 cm depth due to the zero nematode been recorded in site B. According to the results of the SIMPER test, it also pointed out the dissimilarity of the species abundant. In a crossed analysis on the depth of 0-5 cm to 6-10 cm, an average dissimilarity of 96.73 was determined (Table 3.5). The calculated top five species of SIMPER analysis were *D. hirsutum* (12.62 %), *D. tenuispiculum* (10.52 %), *S. macrocirculus* (3.43 %), *Pierrickia vitielloi* (3.20 %) and *Hopperia massiliensis* (2.67 %) (Table 3.5).

In comparison between the studied depth of 0-5 cm and 11-15 cm, the calculated species were same as mentioned above but with higher average of dissimilarity (99.21 %). *Viscosia*

poseidonica, Viscosia stenolaima, Viscosia isotonchula, Viscosia separabilis and *Pomponema polydonta* showed a distinct dissimilarity (93.83 %) in comparing the marine nematode species at the of 6-10 cm and 11-15 cm depth.

Detail on the BioEnv (Biota and/or Environment Matching) test on the relationship between the nematode assemblages to the environment variables within each site using Spearman correlation method subjected to the Euclidean distance matrix was shown in Section 3.2.4. The results of the present study do not conduct the comparison between the marine nematode species and the environmental parameters in each depth.

3.3.4 Analysis of the functional feeding group

Detailed on the percentage of mean species contribution and FFG can be refered to Appendix E3 and Appendix E4. A One-way ANOSIM had been conducted based on the Bray Curtis similarity matrix tested on the mean density of each functional feeding groups (FFG) across sediment depths. Results showed significant difference between the FFG across different depth (calculated $P < 0.001$; R-statistic= 0.35 (Appendix B14). Further analysis was carried out by SIMPER to determine the similarity percentage of FFG across depths. At the depth of 0 - 5 cm, SIMPER showed an average similarity (58.28 %) of three FFG 1B (31.72 %), 2B (14.14 %) and 2A (7.98 %). Nematodes of 2B FFG were dominant in 6 - 10 cm and 11 - 15 cm layers.

Table 3.5: Percentage contribution of dissimilarity of species among depths.

0-5 cm vs 6-10 cm (Average dissimilarity = 96.73)		0-5 cm vs 11-15 cm (Average dissimilarity = 99.21)		6-10 cm vs 11-15 cm (Average dissimilarity = 93.83)	
Species	Contrib %	Species	Contrib %	Species	Contrib %
Daptonema hirsutus	12.62	*Daptonema hirsutus*	16.02	*Viscosia poseidonica*	14.21
Daptonema tenuispiculum	10.52	*Daptonema tenuispiculum*	9.64	*Viscosia stenolaima*	11.52
Sphaerolaimus macrocirculus	3.43	*Sphaerolaimus macrocirculus*	3.2	*Viscosia isotonchula*	11.3
Pierrickia vitielloi	3.2	*Pierrickia vitielloi*	3.11	*Viscosia separabilis*	10.02
Hopperia massiliensis	2.67	*Hopperia massiliensis*	2.54	*Pomponema polydonta*	9.24
Parodontophora pacifica	2.29	*Parodontophora pacifica*	2.24	*Daptonema setifer*	7.23
Sphaerolaimus gracilis	2.26	*Sphaerolaimus gracilis*	2.09	*Stylotheristus mutila*	6.98
Belbolla assupplementata	2.1	*Sabatiera heterura*	2.04	*Sphaerolaimus islandicus*	5.63
Diodontolaimus tunuispiculum	2.1	*Diodontolaimus tunuispiculum*	1.99	*Daptonema tenuispiculum*	5.42
Sabatiera heterura	2.09	*Viscosia antartica*	1.86	*Eudiplogaster* sp 1	4.04
Viscosia stenolaima	1.93	*Viscosia stenolaima*	1.75	*Pomponema tesselatum*	2.81
Viscosia antartica	1.91	*Viscosia epapillosa*	1.62	*Procamacolaimus acer*	2.81
Viscosia epapillosa	1.72	*Sabatieria hilarula*	1.6		
Sabatieria hilarula	1.68	*Belbolla assupplementata*	1.55		
Viscosia stenostoma	1.49	*Viscosia stenostoma*	1.44		
Sabatieria furcillata	1.44	*Daptonema curvispiculum*	1.3		
Daptonema curvispiculum	1.44	*Trichotheristus mirabilis*	1.26		
Spilophorella candida	1.32	*Spilophorella candida*	1.25		
Trichotheristus mirabilis	1.31	*Daptonema riemanni*	1.16		
Daptonema normandicus	1.22	*Daptonema normandicus*	1.15		
Daptonema riemanni	1.19	*Daptonema oxycerca*	1.08		
Daptonema fissendens	1.18	*Daptonema grahami*	1.08		
Daptonema oxycerca	1.14	*Daptonema fissendens*	1.07		
Sabatieria paradoxa	1.05	*Sphaerolaimus pacificus*	1.06		
Parodontophora xenoticha	1.03	*Parodontophora xenoticha*	1.03		

Sphaerolaimus pacificus	1.02	*Sabatieria paradoxa*	1.02
Daptonema grahami	1.01	*Sabatieria longicaudata*	0.97
Sabatieria longicaudata	1.01	*Viscosia cobbi*	0.96
Daptonema setifer	0.97	*Daptonema setifer*	0.95
Viscosia cobbi	0.95	*Sabatieria furcillata*	0.93
Daptonema conicum	0.93	*Daptonema conicum*	0.88
Sabatieria stekhoveni	0.89	*Sabatieria stekhoveni*	0.85
Daptonema uncinatus	0.8	*Daptonema laxus*	0.85
Daptonema laxus	0.79	*Daptonema uncinatus*	0.79
Trichotheristus erectus	0.74	*Trichotheristus erectus*	0.72
Viscosia separabilis	0.68	*Sphaerolaimus islandicus*	0.69
Sphaerolaimus islandicus	0.68	*Sphaerolaimus horrendus*	0.69
Dorylaimidae sp 1	0.67	*Sabatieria intermissa*	0.65
Sabatieria intermissa	0.66	*Viscosia langrunensis*	0.63
Sphaerolaimus horrendus	0.66	*Paracomesoma longispiculum*	0.61
Viscosia langrunensis	0.66	*Trichotheristus galeatus*	0.61
Viscosia tumidula	0.63	*Viscosia tumidula*	0.61
Paracomesoma longispiculum	0.63	*Dorylaimidae* sp 1	0.61
Trichotheristus galeatus	0.63	*Oxystomina elongata*	0.6
Oxystomina elongata	0.63	*Pierrickia aequalis*	0.6
Pierrickia aequalis	0.62	*Trichotheristus floridanus*	0.59
Trichotheristus floridanus	0.62	*Sabatiera intermissa*	0.59
Sabatiera intermissa	0.61	*Sphaerolaimus lamasus*	0.59
Sphaerolaimus lamasus	0.61	*Viscosia erasmi*	0.56
Sphaerolaimus balticus	0.56	*Oxystomina asetosa*	0.55
Viscosia erasmi	0.54	*Sphaerolaimus balticus*	0.53
Marylynnia sp	0.53	*Marylynnia* sp	0.5
Drepanodorylaimus sp 1	0.5	*Viscosia isotonchula*	0.5
Sabatieria punctata	0.5	*Daptonema vicinus*	0.48
Promonhystera tricuspidata	0.5	*Parodontophora quadristicha*	0.48

Oxystomina asetosa	0.5	*Promonhystera tricuspidata*	0.48
Eumorpholaimuss sabulicolus	0.48	*Drepanodorylaimus* sp 1	0.48
Symplocastoma brevispiculum	0.48	*Sabatieria punctata*	0.48
Daptonema vicinus	0.47	*Calyptronema cobbi*	0.46
Parodontophora quadristicha	0.47	*Viscosia poseidonica*	0.44
Pomponema polydonta	0.45	*Eumorpholaimuss sabulicolus*	0.43
Calyptronema cobbi	0.45	*Symplocastoma brevispiculum*	0.43
Parodontophora brevamphida	0.43	*Parodontophora brevamphida*	0.41
Dracognomus dermatoglyphus	0.42	*Dracognomus dermatoglyphus*	0.4
Rhips gracilicauda	0.42	*Rhips gracilicauda*	0.4
		Spilophorella tasmaniensis	0.4
		Viscosia poseidonica	0.4
		Daptonema sentiens	0.39

3.4 Seasonal study of marine nematode community structure in Teluk Awar

3.4.1 Sandy site

A monitoring of 16 months (from July 2008 - October 2009) was carried out in the sandy site of Teluk Awar. One-way ANOVA analyses showed that pH, DO, temperature and salinity were significantly different among months (Appendix A6). The pH of the seasonal study in the sandy site was recorded to be significant difference between months. The pH reading decreased from year 2008 to 2009 with the highest reading in January 2009 (Table 3.6). The highest DO level was recorded during July and August for the both study years. The *in situ* temperature of the site showed an average of 30 °C and above during the dry season of each year. Salinity reading was recorded lower in 2008 during the dry season compared to 2009. Detailed of the mean readings of each parameters can be obtained in Table 3.6.

Statistical results showed that both TOM and chl *a* were significant difference between months. The highest amount of TOM was detected in July 2008, June 2009 and September 2009. However, the chl *a* concentration was recorded to be the highest in November 2008, January 2009, May 2009 and August 2009 (Table 3.6).

Table 3.6: Mean reading on the abiotic and biotic data for the sandy site including the rainfall and monthly surface temperature.

	Abiotic													Biotic			
Months	pH	S.D	DO	S.D	Temperature	S.D	Salinity	S.D	Rainfall	Surface Temperature	Sand	Silt	Clay	TOM	S.D	Chl *a*	S.D
Jul-08	9.46	±0.13	1.49	±0.10	32.79	±0.10	30.00	±0.00	183.50	26.20	27.98	61.47	10.53	2.26	±0.23	0.11	±0.00
Aug-08	9.17	±0.08	1.40	±0.28	35.44	±0.01	26.50	±0.71	326.40	26.40	56.96	37.73	5.30	1.67	±0.12	1.13	±0.55
Sep-08	9.17	±0.08	1.10	±0.28	35.44	±0.01	27.50	±0.71	207.80	26.40	70.24	24.14	5.61	1.38	±0.06	1.42	±1.13
Oct-08	9.19	±0.01	0.80	±0.00	36.11	±0.98	28.00	±0.00	307.20	26.30	52.01	42.31	5.67	1.00	±0.04	4.50	±2.25
Nov-08	9.21	±0.02	0.85	±0.07	37.82	±0.11	21.00	±0.00	482.40	26.30	70.21	28.93	0.84	1.43	±0.00	8.02	±3.66
Dec-08	9.10	±0.05	1.00	±0.14	31.45	±0.04	25.00	±0.00	516.20	25.70	62.54	36.43	1.02	0.18	±0.07	3.75	±2.13
Jan-09	9.67	±0.01	0.75	±0.07	28.20	±0.01	18.00	±0.00	1130.00	25.10	71.00	27.30	1.69	1.11	±0.04	8.05	±1.01
Feb-09	9.02	±0.57	0.80	±0.14	24.82	±0.01	20.00	±0.00	390.00	26.00	57.65	39.92	2.42	1.60	±0.01	2.35	±1.87
Mar-09	8.10	±0.06	0.95	±0.07	32.00	±0.14	18.00	±0.00	304.60	26.00	53.22	44.90	1.86	1.79	±0.04	0.51	±0.09
Apr-09	7.87	±0.01	0.75	±0.07	28.75	±0.21	24.00	±0.00	418.20	26.80	58.91	38.90	2.19	1.58	±0.04	6.62	±2.84
May-09	7.26	±0.04	0.85	±0.07	33.00	±0.00	26.00	±0.00	253.60	27.10	63.02	35.90	1.07	1.84	±0.44	9.98	±10.35
Jun-09	8.45	±0.07	0.40	±0.14	31.00	±0.14	30.50	±0.71	318.80	27.40	59.68	36.36	3.95	2.03	±0.04	0.36	±0.15
Jul-09	8.55	±0.07	1.35	±0.07	32.10	±0.00	30.00	±0.00	157.60	27.10	58.23	38.40	3.35	1.57	±0.21	1.26	±1.05
Aug-09	7.81	±0.00	1.30	±0.28	29.10	±0.00	30.00	±0.00	231.20	27.20	57.78	39.96	2.25	1.79	±0.21	7.35	±0.39
Sep-09	7.16	±0.02	0.80	±0.14	29.10	±0.00	31.00	±0.00	133.40	27.40	42.29	53.71	3.99	2.22	±0.37	1.22	±0.33
Oct-09	7.98	±0.01	0.75	±0.07	34.75	±0.07	25.00	±0.00	625.20	26.50	49.89	46.61	3.50	1.95	±0.11	1.34	±0.85

* DO – dissolved oxygen, S.D. – Standard deviation, TOM – total organic matter, Chl *a* – chlorophyll *a*

The percentage contribution of the particle fractions of the study site are listed in Table 3.6. The study site was determined to be a sandy-silt beach. The results showed that the site were dominated by higher percentage of sand from September 2008 to January 2009. November 2008 and January 2009 were dominated by higher percentage of fine (0.125 mm) and very fine sand (0.063mm) (Figure 3.21). Coarser sand fractions were recorded in September 2008. The study site was recorded to be dominated by silt in July 2008, September 2009 and October 2009. In the other months, the study site was recorded to be dominated by a slightly higher percentage of very fine sand (0.063 mm) together with the silt content.

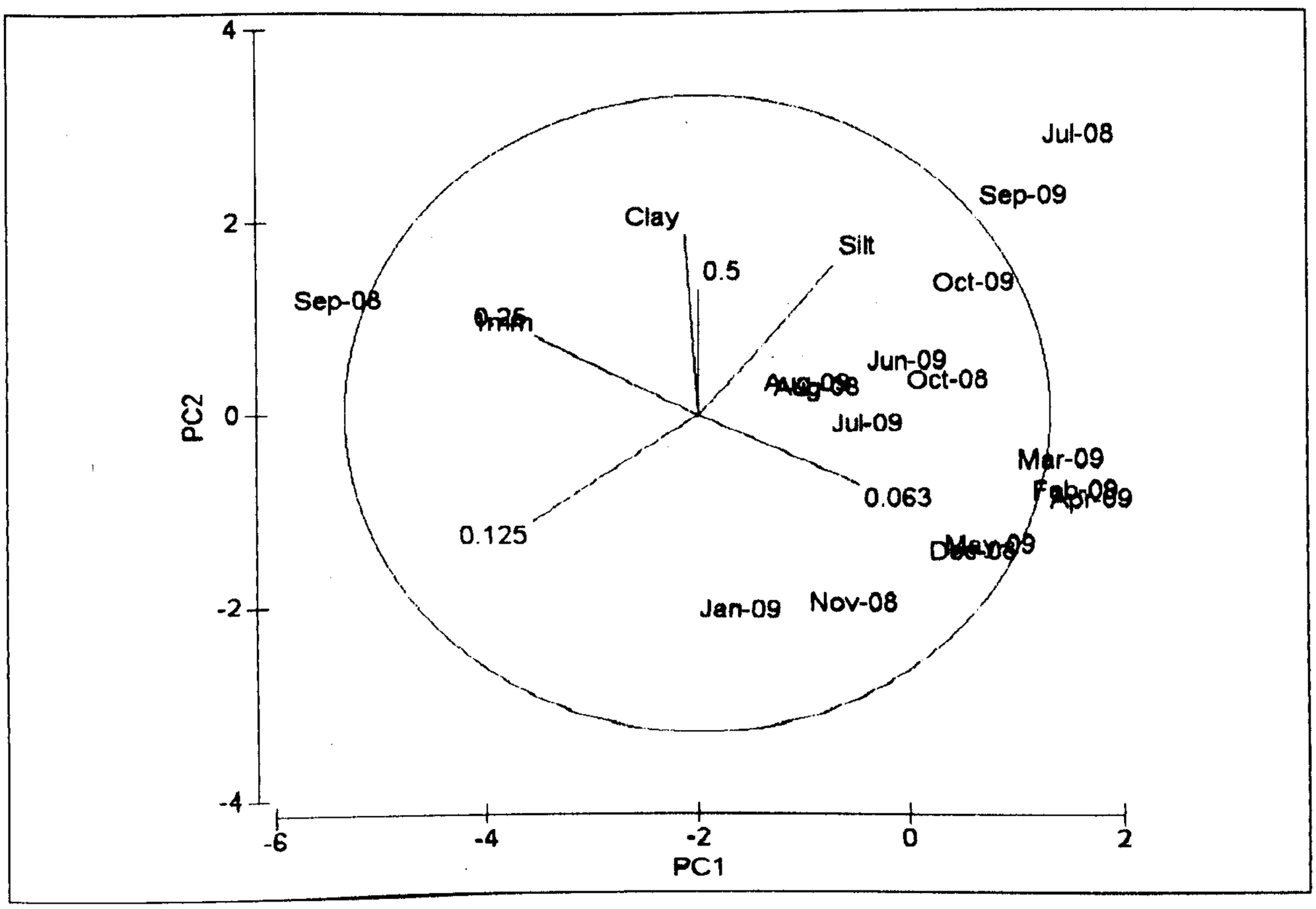

Figure 3.21: The principal component analysis of particle size fractions over months subject to the PC1 and PC2 with the cumulative variations of 73.5 %.

The results of the study showed that the mean densities of the marine nematode were at the highest peak during July 2008 and 2009. Figure 3.22a showed that the highest density of

marine nematode was recorded during the dry season (where the mean rainfall data recorded 183.5 mm and the later at 157.6 mm) (Figure 3.22a). The lowest marine nematode density was recorded in November 2008 and the situation continued until March 2009. The rainfall started to increase since November 2008 and the highest rainfall was recorded in January 2009 (1130.6 mm). The monthly mean surface temperature did not show a significant correlation to the marine nematode densities. However, the monthly surface temperature August and September 2009) were higher than the year of 2008 at the same months (Figure 3.22b). The total nematode densities remained the highest during the dry season in 2009 yet lower compared to 2008.

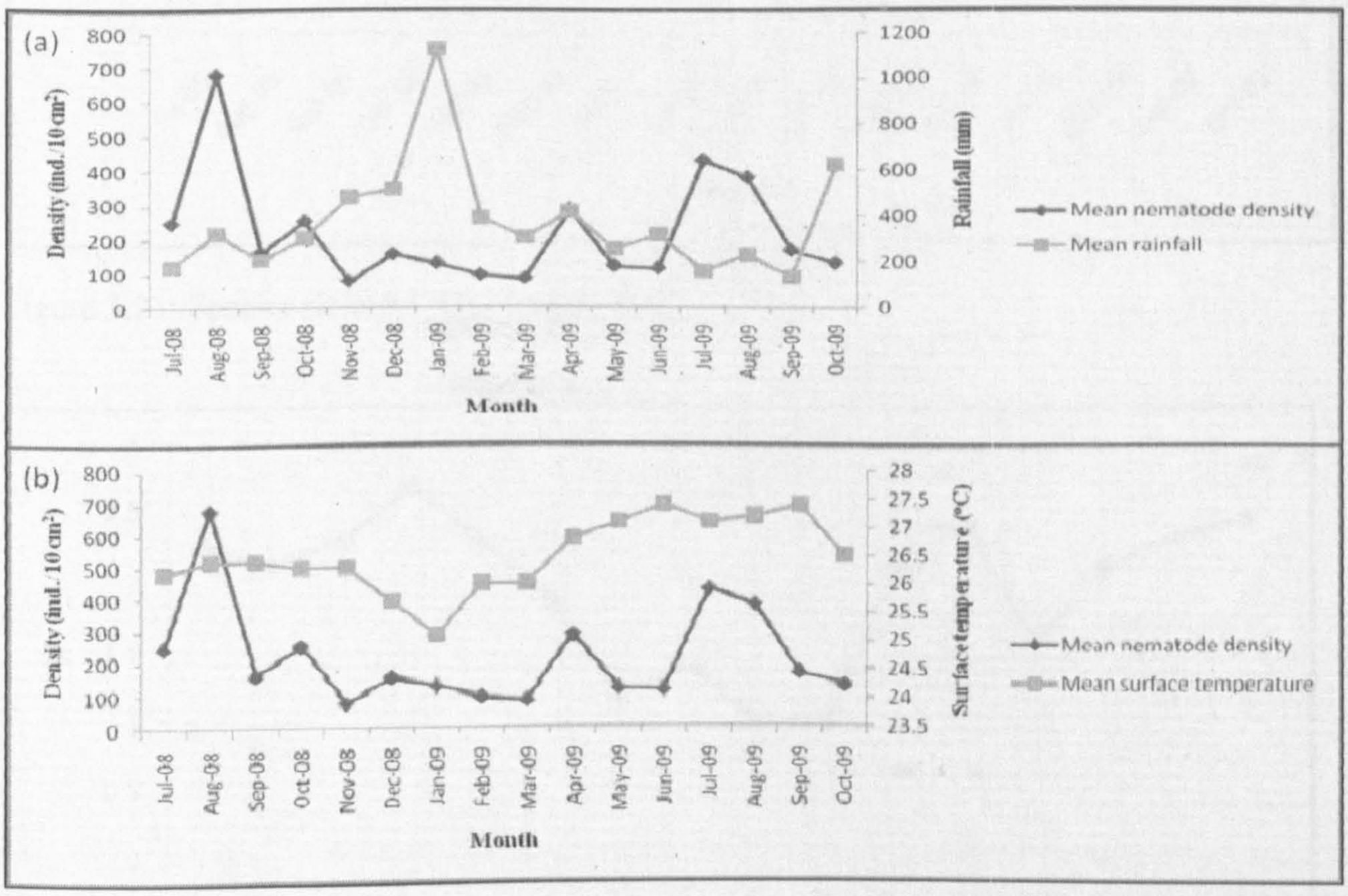

Figure 3.22: (a) The mean nematode density (ind. /10 cm^2) and the mean rainfall data (millimeter). (b) The mean nematode density (ind. /10 cm^2) and the monthly mean temperature.

The species richness was recorded to be lowest during March 2009 (Figure 3.23). The diversity index of the study was below 2.0 from December 2008 until April 2009 and also July 2009 (Figure 3.24). The evenness of the species dropped to the lowest in April 2009 (Figure 3.25).

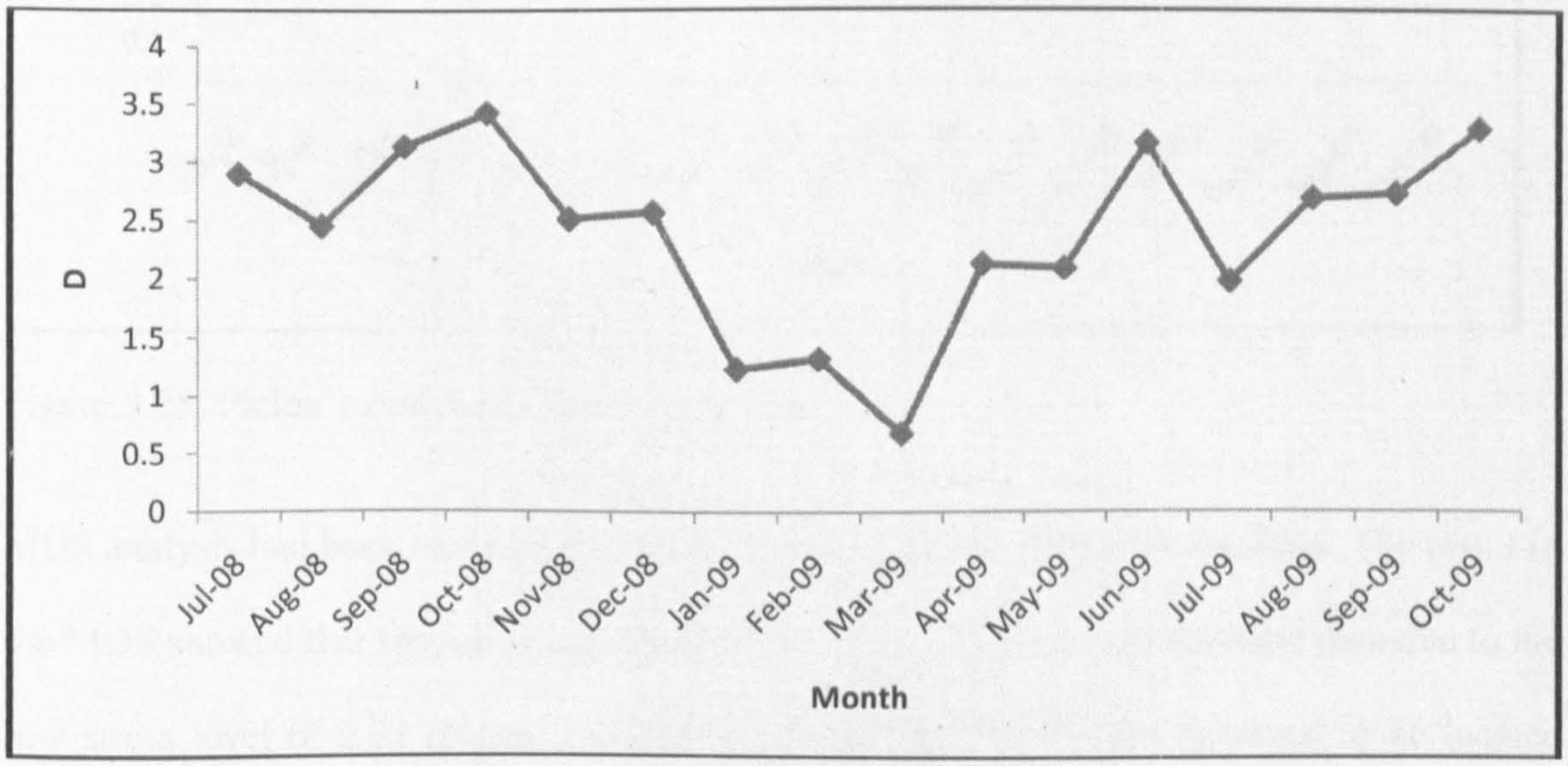

Figure 3.23: Species richness (D) of sandy site.

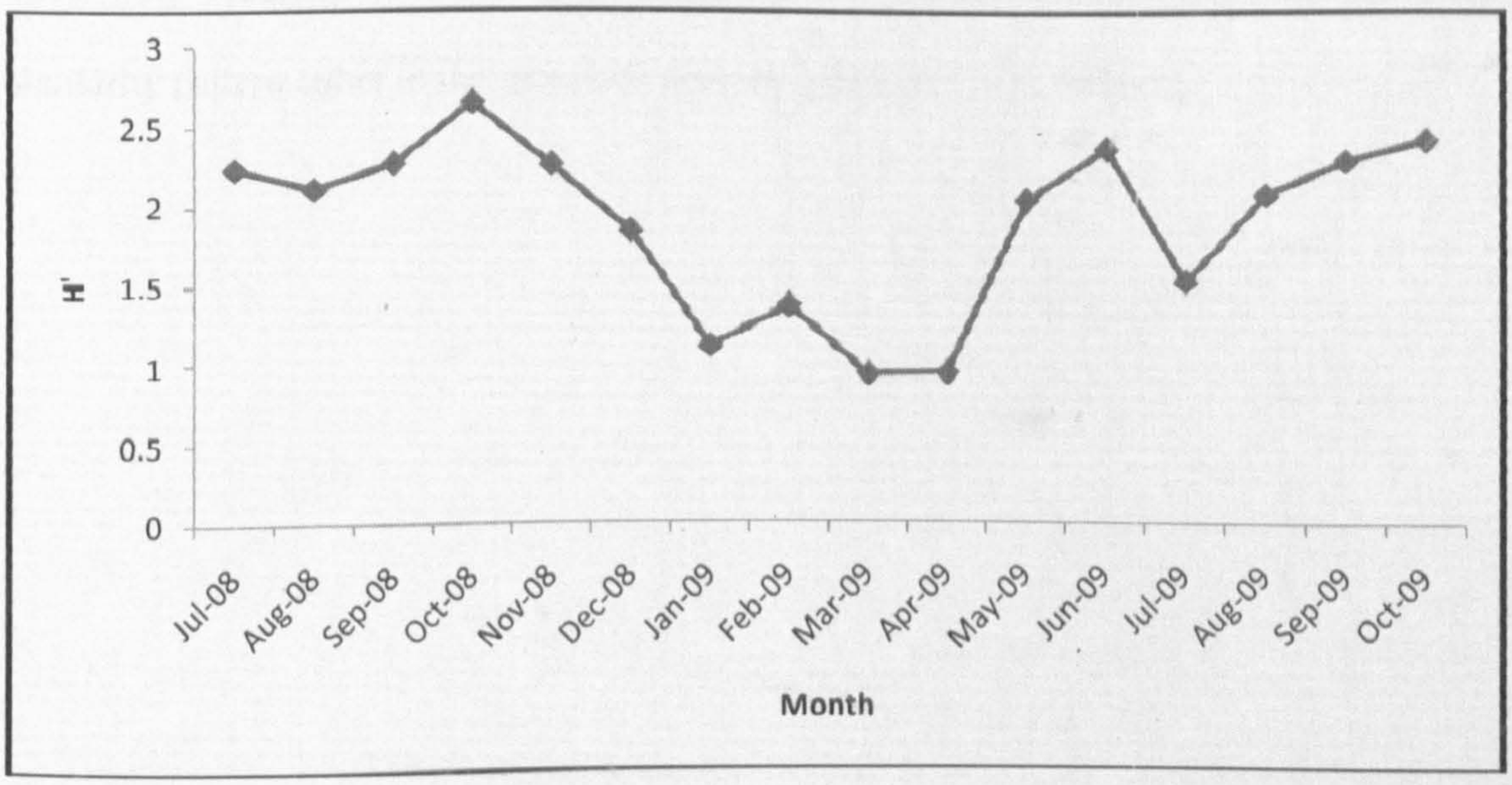

Figure 3.24: Shannon-Weiner species diversity index (H') of sandy site.

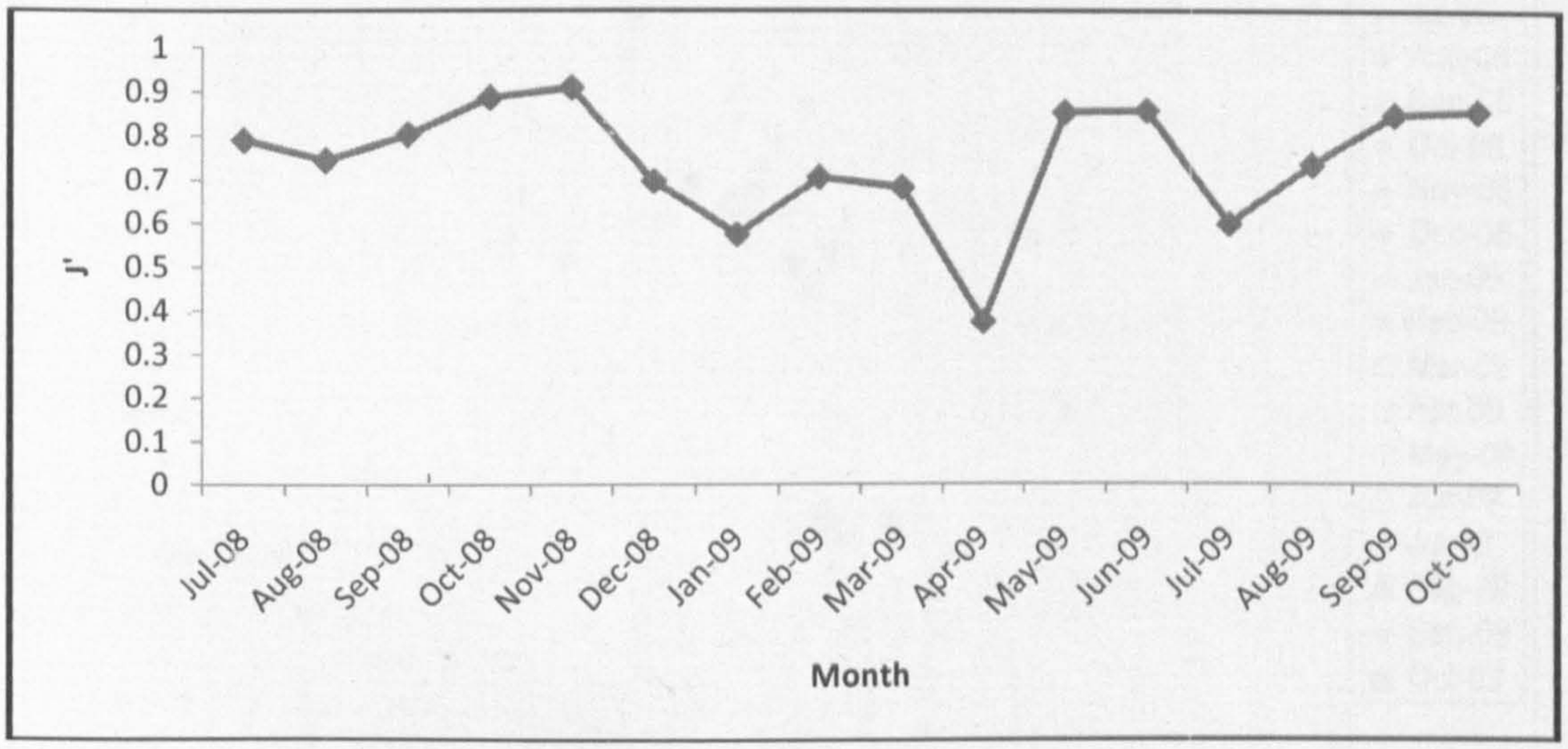

Figure 3.25: Pielou's evenness (J') of sandy site.

MDS analysis had been conducted using the three replicates of species densities. The result of the MDS showed that two-dimensional ordination was enough to represent the data due to the low stress level of 0.22 (Figure 3.26). July and October 2008 were observed to be located separately with the other groups. August 2008, September 2008, July 2009 and September 2009 were recorded to be clustered together as a group. The groupings showed on the similarity pattern either in the nematode species abundance or richness.

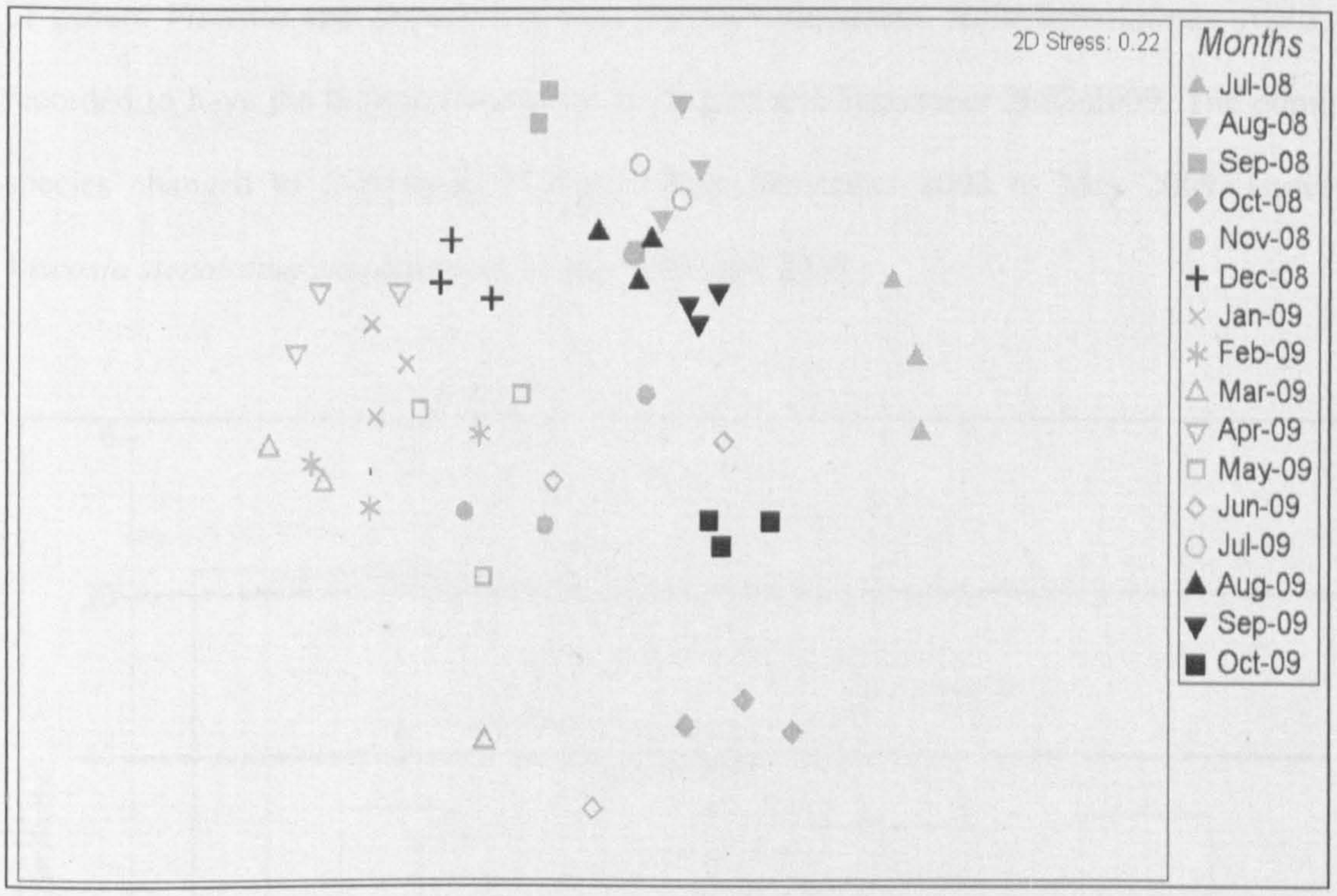

Figure 3.26: Two-dimensional MDS ordination of the similarity matrix constructed from the three replicates density study of each nematode species in the sandy site of Teluk Awar.

A detailed study on the distribution pattern of Figure 3.26 was explained in Figure 3.27. A dendrogram was produced based on the hierarchical clustering to determine the similarity percentage of the marine nematode abundance in the 16 months' study. At the approximate of 20 percent similarity level, three grouping were recorded. A total of 14 groups were demónstrated to be clustered together at 60 percent of similarity level (Figure 3.27).

Analysis of similarity showed that the marine nematode density was significant difference between months in the study site (calculated *p*-value= 0.001; *R*-statistic =0.735) (Appendix B15). A further analysis of similarity percentage had been conducted to determine the dominancy of species in each study month. Detailed of the marine nematode species similarity percentage was shown in Table 3.7. The results showed that the marine nematode

of genera *Viscosia* and *Daptonema* were the most dominant. *Halichoanolaimus ovalis* was recorded to have the highest abundance in August and September 2008/2009. The dominant species changed to *Daptonema hirsutum* from December 2008 to May 2009. However, *Viscosia stenolaima* was dominant in July 2008 and 2009.

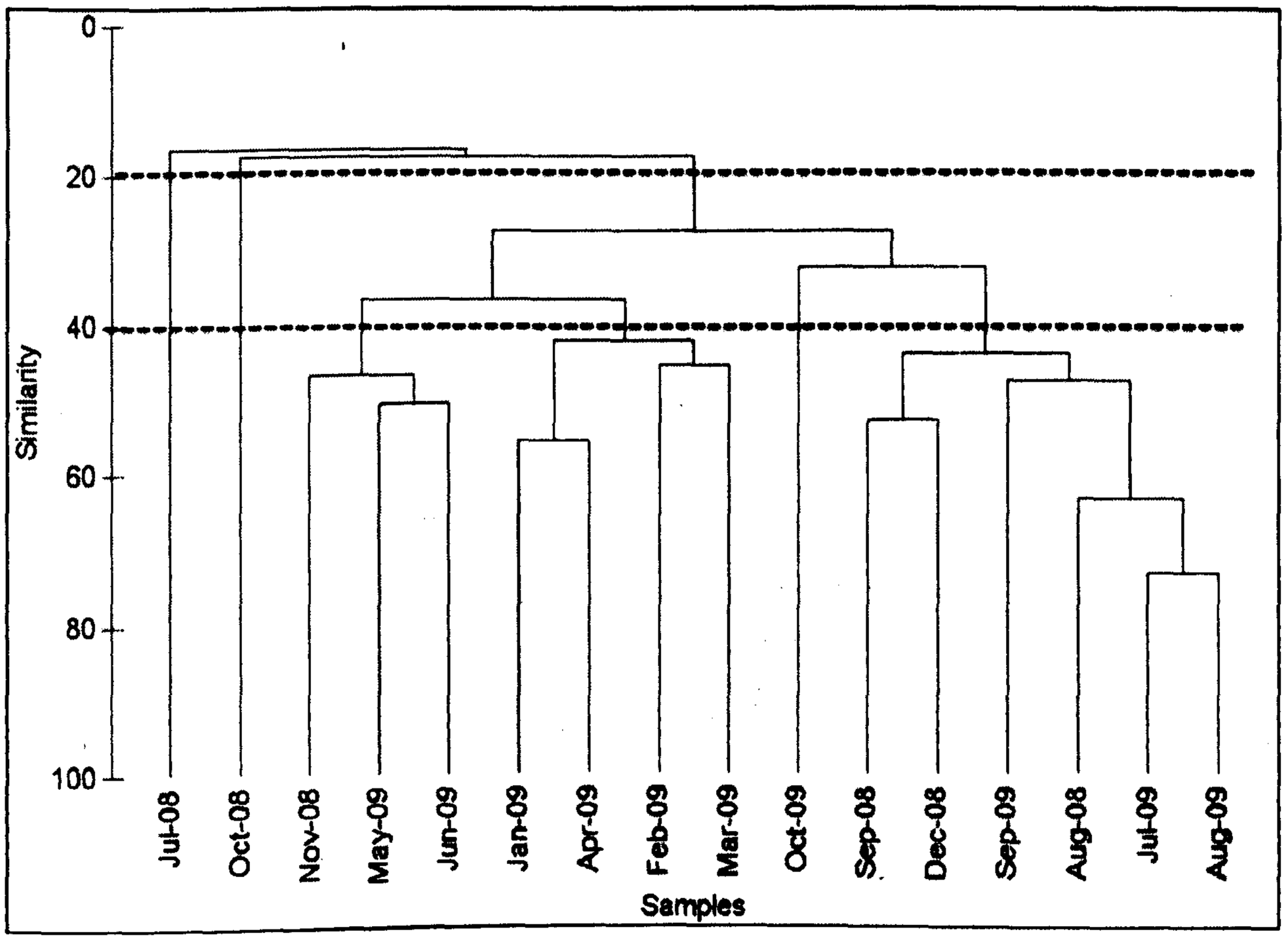

Figure 3.27: Dendrogram produced by Cluster Analysis for seasonal study (sandy site).

Table 3.7: The average similarity of marine nematode species on the sandy site in each studied months.

Month & average similarity	Nematode species
Group Jul-08 Average similarity: 32.40	*Viscosia stenolaima* *Wieseria stenolaima* *Halichoanolaimus ovalis*
Group Aug-08 Average similarity: 69.86	*Viscosia viscosa* *Sphaerolaimus lodosus* *Viscosia tumidula* *Viscosia coomansi* *Viscosia stenolaima* *Parodontophora pacifica*
Group Sep-08 Average similarity: 41.65	*Halichoanolaimus ovalis* *Viscosia viscosa* *Parodontophora pacifica* *Sphaerolaimus lodosus* *Sphilophorella paradoxa*
Group Oct-08 Average similarity: 49.39	*Spirinia parasitifera* *Dorylaimid* sp 1 *Viscosia keiensis* *Sphaerolaimus macrocirculus* *Pomponema ammophilum* *Haliplectus floridanus* *Terschellingia longicaudata* *Parodontophora breviseta* *Perspiria megamphida* *Wieseria longicaudata* *Eudiplogaster* sp 1 *Parodontophora pacifica*
Group Nov-08 Average similarity: 35.56	*Sphaerolaimus macrocirculus* *Viscosia stenolaima* *Daptonema hirsutum* *Viscosia viscosa*
Group Dec-08 Average similarity: 60.67	*Daptonema hirsutum* *Viscosia viscosa* *Halichoanolaimus ovalis* *Viscosia stenolaima*
Group Jan-09 Average similarity: 64.94	*Daptonema hirsutum* *Viscosia stenolaima* *Viscosia viscosa*
Group Feb-09 Average similarity: 60.96	*Daptonema hirsutum* *Parodontophora pacifica* *Sabatieria lawsi*
Group Mar-09 Average similarity: 39.47	*Daptonema hirsutum* *Daptonema tenuispiculum*

	Sphaerolaimus macrocirculus
Group Apr-09 Average similarity: 47.97	*Daptonema hirsutum* *Viscosia viscosa*
Group May-09 Average similarity: 38.27	*Daptonema hirsutum* *Viscosia stenolaima* *Sabatieria lawsi* *Parodontophora pacifica* *Sphaerolaimus gracilis*
Group Jun-09 Average similarity: 18.22	*Viscosia stenolaima* *Dorylaimid* sp 1 *Sphaerolaimus macrocirculus* *Parodontophora pacifica* *Pomponema coomansi*
Group Jul-09 Average similarity: 61.13	*Halichoanolaimus ovalis* *Viscosia stenolaima* *Viscosia viscosa* *Viscosia tumidula* *Sphaerolaimus lodosus* *Sphaerolaimus macrocirculus*
Group Aug-09 Average similarity: 70.42	*Halichoanolaimus ovalis* *Sphaerolaimus lodosus* *Viscosia stenolaima* *Viscosia tumidula* *Sabatieria lawsi* *Sphaerolaimus macrocirculus* *Viscosia viscosa*
Group Sep-09 Average similarity: 64.35	*Halichoanolaimus ovalis* *Viscosia stenolaima* *Sphaerolaimus macrocirculus* *Parodontophora breviseta* *Viscosia erasmi* *Viscosia tumidula* *Dorylaimid* sp 1
Group Oct-09 Average similarity: 49.13	*Parodontophora pacifica* *Viscosia erasmi* *Dorylaimid* sp 1 *Daptonema astrodes* *Sphaerolaimus macrocirculus*

Result of a BioEnv test showed that certain environmental parameters were correlated with the nematode species abundance (Appendix C4). The calculated result showed that five parameters were greatly influencing the marine nematode species abundance in Teluk Awar

(mean DO, mean temperature, mean salinity and particle size fractions) (correlation=0.588) (Appendix C4).

Detail on the mean percentage on each nematode species contribution and FFG are listed in Appendix E5. Percentages of FFG of the marine nematode were used to conduct a principal component analysis (excluding the freshwater nematode). The study area was dominated by the marine nematode of FFG 1A in July 2008 while FFG of 1B was recorded high during January – April 2009 (Figure 3.28). Nematode of FFG 2A was dominant in October 2008. Most of the study months (especially during the dry season) were recorded to be dominated by the species with the FFG of 2B.

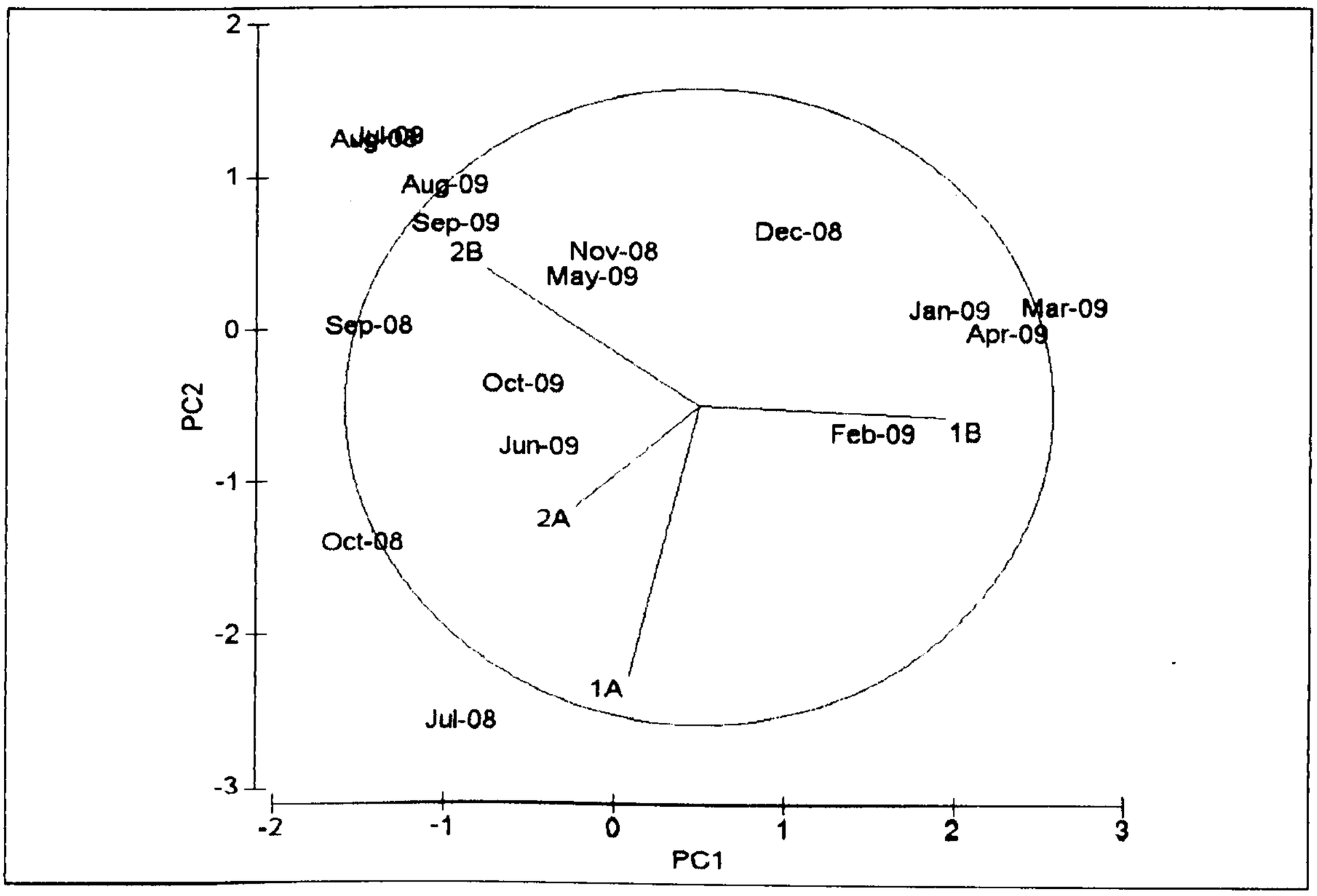

Figure 3.28: Principle component analysis plot derived from the mean percentage contribution of the functional feeding group (FFG) of nematode species from each site and stations (sandy site).

3.4.2 Muddy site

Detail of the abiotic and biotic parameters reading are recorded in Table 3.8. A similar monitoring process was carried out as mentioned in Section 3.4.1.The result of the one-way ANOVA showed that the physico-chemical parameters of the muddy site were significantly different between months (Appendix A7).

The highest reading of pH was recorded in July 2008 but decreased until October 2008. It rose up again since November 2008 until February 2009. After that, it started to decrease until the last sampling month which fell on October 2009. The DO was recorded to be low all over the studied period. The the highest *in situ* mean temperature was recorded in July 2008 (35.6 °C). The highest salinity (36 PSU) also only recorded in July 2008. TOM was recorded be high from February to July 2009 compared to the other sampling months. Highest chl *a* concentration was documented in August 2009 (10.95 mg/m^3).

Table 3.8: Mean reading on the abiotic and biotic data for the muddy site including the rainfall and monthly surface temperature.

	Abiotic													Biotic			
Months	pH	S.D	DO	S.D	Temperature	S.D	salinity	S.D	Rainfall	Surface temperature	Sand	Silt	Clay	TOM	S.D	Chl *a*	S.D
Jul-08	9.59	±0.01	0.40	±0.00	35.60	±0.00	36.00	±0.00	183.50	26.20	5.26	87.96	6.78	1.42	±0.12	0.87	±0.44
Aug-08	8.11	±0.01	0.45	±0.07	29.57	±0.01	22.00	±2.83	326.40	26.40	18.36	77.68	3.95	2.22	±0.13	1.07	±0.19
Sep-08	8.17	±0.06	0.45	±0.21	28.76	±0.02	17.00	±1.41	207.80	26.40	52.95	42.12	4.92	2.17	±0.07	0.66	±0.39
Oct-08	7.99	±0.04	0.35	±0.07	29.66	±0.01	16.50	±0.71	307.20	26.30	27.50	60.71	11.77	0.47	±0.08	2.11	±0.29
Nov-08	8.20	±0.01	0.60	±0.28	29.53	±0.69	14.50	±0.71	482.40	26.30	32.77	63.02	4.21	3.29	±0.10	2.24	±0.36
Dec-08	8.25	±0.04	0.55	±0.35	30.84	±0.03	14.00	±0.00	516.20	25.70	23.65	72.08	4.27	0.47	±0.08	0.97	±0.00
Jan-09	8.54	±0.32	0.40	±0.14	28.16	±0.05	15.00	±0.00	1130.60	25.10	21.35	74.10	4.54	2.94	±0.05	1.08	±0.27
Feb-09	8.83	±0.18	0.50	±0.14	25.39	±0.01	16.00	±0.00	390.00	26.00	29.71	66.81	3.49	4.19	±0.78	1.32	±0.07
Mar-09	7.78	±0.16	0.45	±0.21	28.40	±0.14	13.50	±0.71	304.60	26.00	33.22	62.54	4.24	3.46	±0.09	1.68	±0.62
Apr-09	7.18	±0.05	0.60	±0.14	28.45	±0.07	18.00	±0.00	418.20	26.80	29.62	67.32	3.06	4.09	±0.40	1.30	±0.10
May-09	7.07	±0.00	0.35	±0.07	27.00	±0.00	24.50	±0.71	253.60	27.10	16.13	77.56	6.31	2.39	±0.26	2.29	±1.33
Jun-09	7.20	±0.00	0.10	±0.00	28.25	±0.07	28.00	±0.00	318.80	27.40	32.50	62.03	5.47	4.25	±0.37	1.42	±1.55
Jul-09	7.35	±0.07	0.05	±0.07	29.50	±0.00	25.50	±0.71	157.60	27.10	24.92	70.14	4.94	3.45	±0.37	1.85	±0.32
Aug-09	7.00	±0.14	0.15	±0.07	29.10	±0.00	29.00	±0.00	231.20	27.20	25.23	68.52	6.25	2.16	±0.44	10.95	±6.20
Sep-09	6.92	±0.01	0.15	±0.07	29.10	±0.00	30.00	±0.00	133.40	27.40	35.37	57.85	6.78	2.05	±0.16	3.70	±1.29
Oct-09	6.92	±0.00	0.80	±0.14	29.70	±0.00	21.00	±0.00	625.20	26.50	9.78	82.40	7.82	2.40	±0.18	0.29	±0.16

* DO – dissolved oxygen, S.D. – Standard deviation, TOM – total organic matter, Chl *a* – chlorophyll *a*

Particle size analyses were conducted and the results had been converted into percentage of fraction contribution to reduce the errors caused by the different weight of the samples. Overall, the samples showed that the study site was dominated by the silt fraction except September 2008 (sand dominate) throughout the sampling periods. Details of the particles' distribution are recorded in Figure 3.29. The result of the PCA showed on 65.9 percent of cumulative variation for PC 1 and 2.

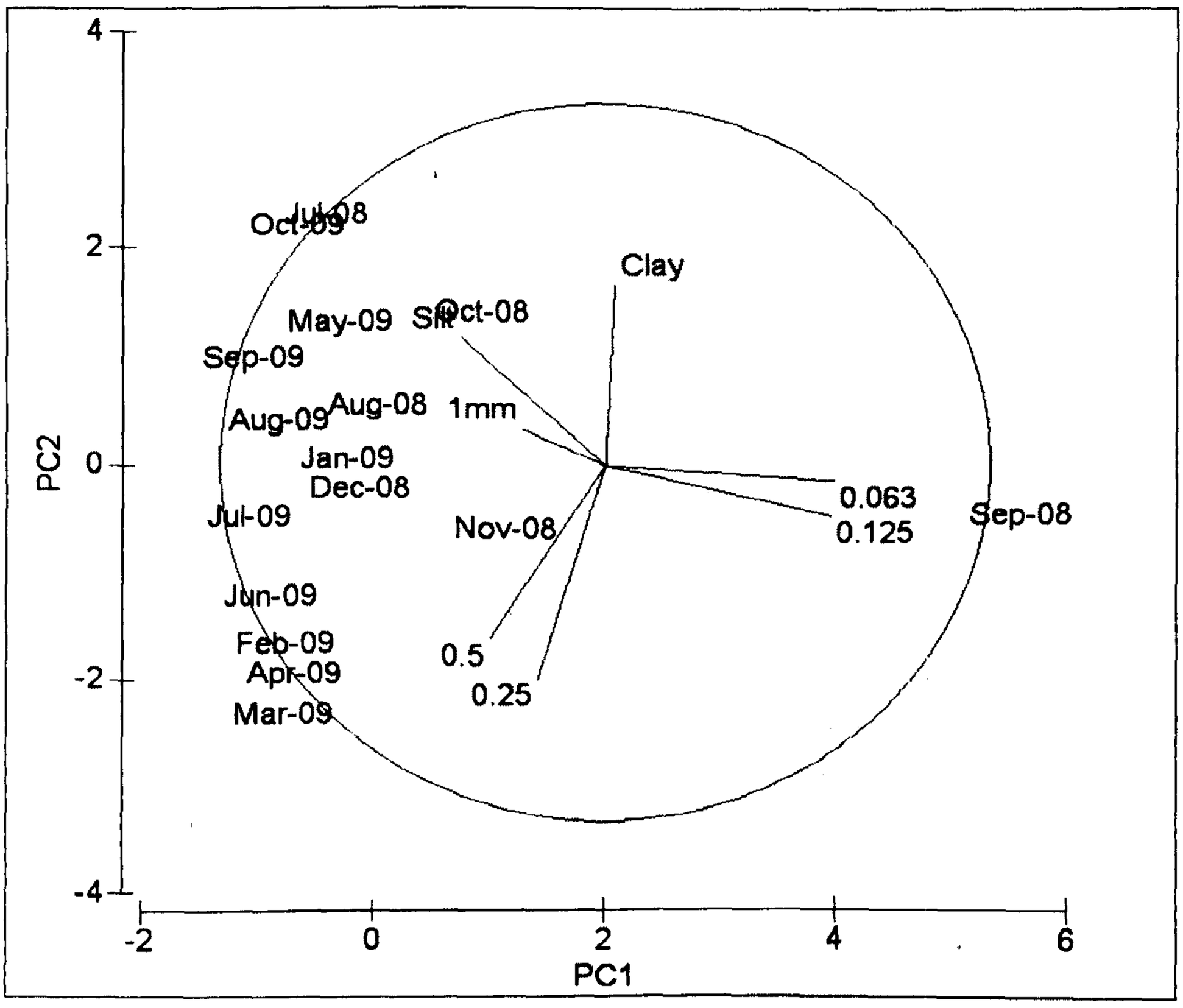

Figure 3.29: Principle component analysis plot derived from the mean percentage contribution of the particle size fractions from each site and station with 65.9 % of cumulative variation

The temporal study of marine nematode in the muddy site showed that the mean densities were at the peak during November 2008 and October 2009 followed by April and May 2009. The lowest density was recorded in October 2008. During the rainy season, (December 2008 – February 2009) the densities dropped (Figure 3.30a). In comparison with the monthly mean surface temperature, the marine nematode did not show a significant correlation. However, the average surface temperature of year 2009 increased at the mid of the year. July - September 2009s' temperatures were recorded to be higher than the previous year (2008) (± 1°C). The mean densities also been recorded to be higher during the mid of 2009 (July – September) compared to 2008 (Figure 3.30b).

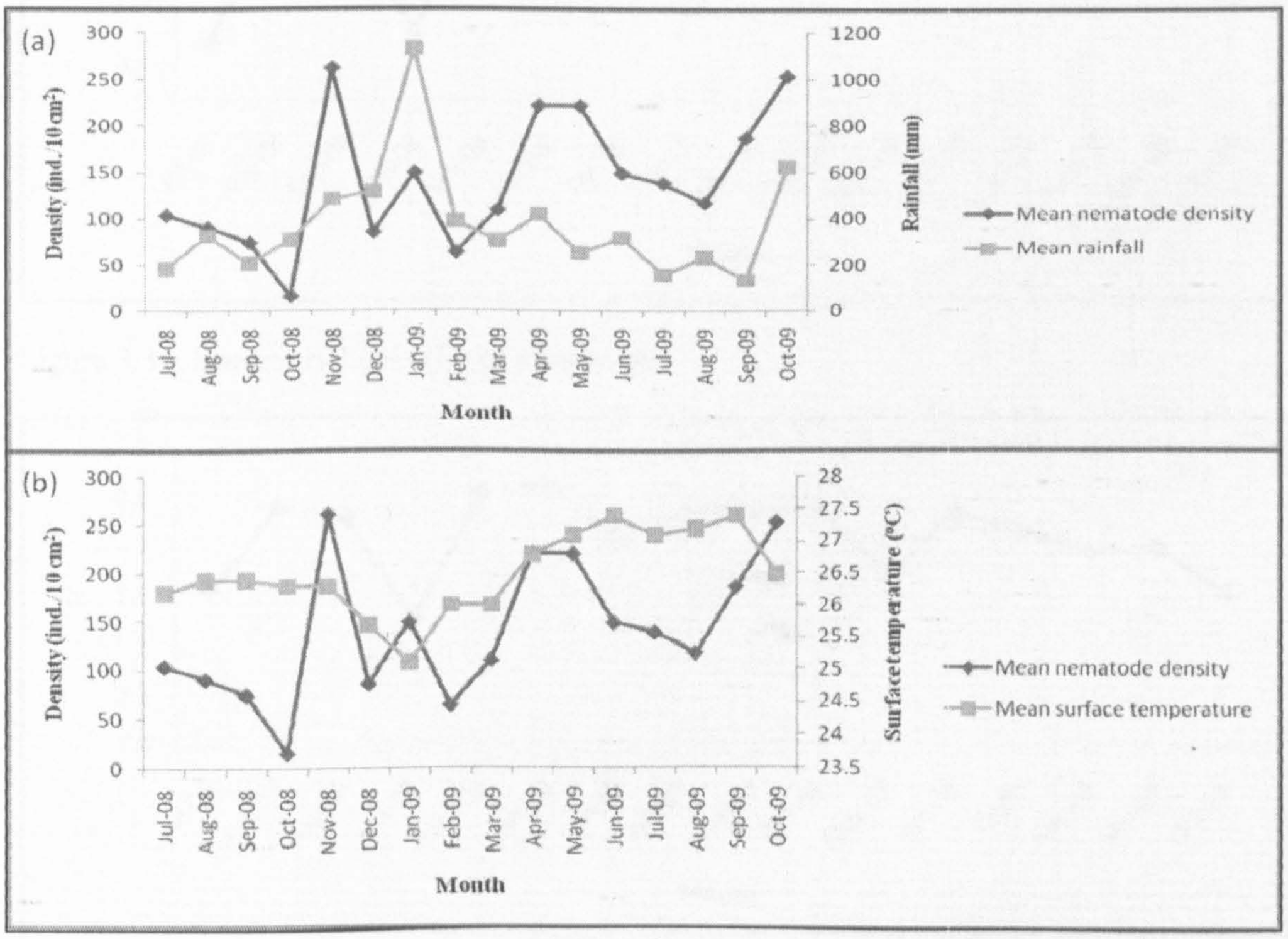

Figure 3.30: (a) The mean nematode density (ind. /10 cm^2) of muddy site and the mean rainfall data (millimeter). (b) The mean nematode density (ind. /10 cm2) of muddy site and the monthly mean temperature.

DIVERSE analyses showed that the lowest species number were detected in July and October 2008. The highest species number was detected in April 2009 while the lowest in July 2008 (Figure 3.31). The Shannon-Weiner species diversity index of July (08), October (08), May (09), August (09), September (09) and October (09) were recorded to be lower than 2.0 (Figure 3.32). Pielou's evenness showed highest reading in July 2008 and lowest in October 2009 (Figure 3.33).

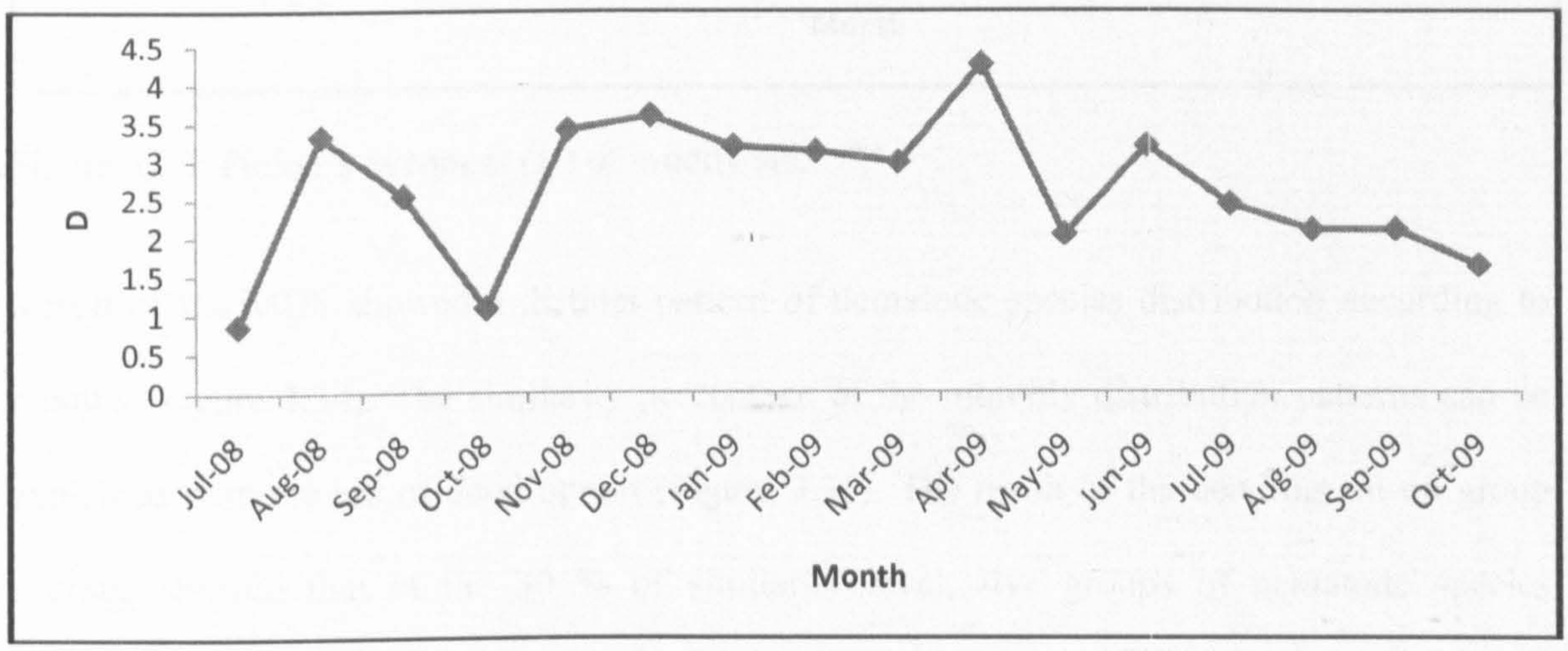

Figure 3.31: Species richness (D) of muddy site.

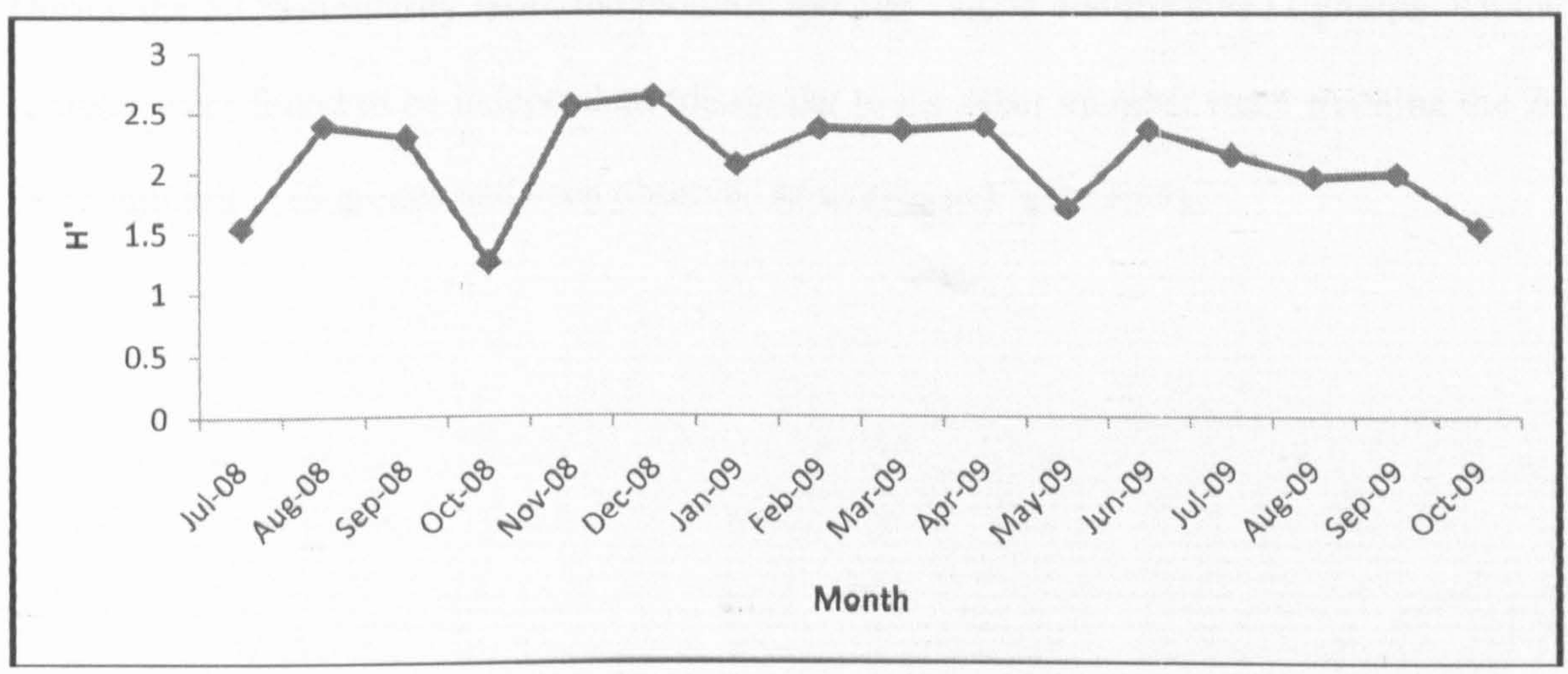

Figure 3.32: Shannon-Weiner diversity index (H') of muddy site.

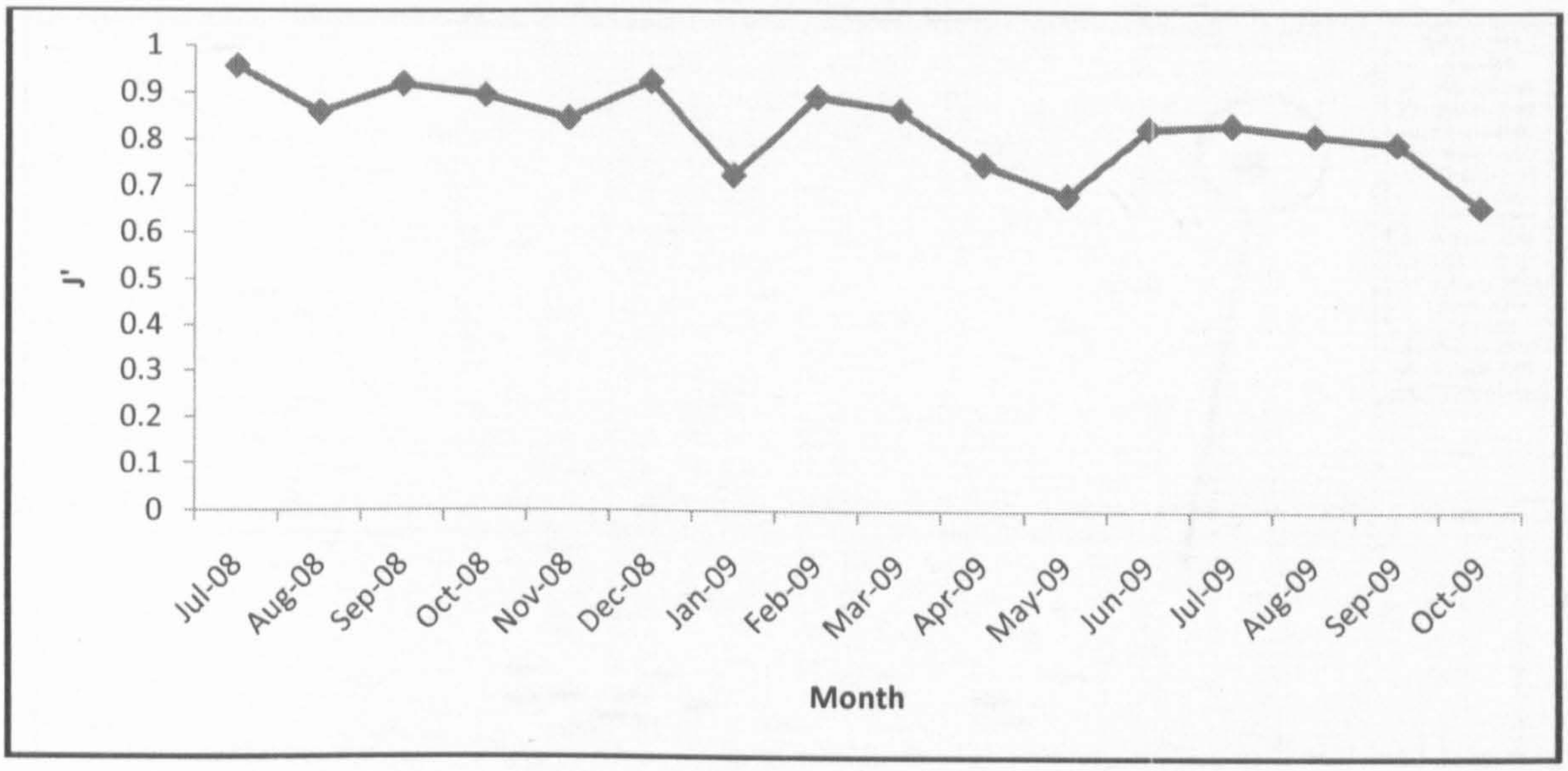

Figure 3.33: Pielou's evenness (J') of muddy site.

Result of the MDS showed a distinct pattern of nematode species distribution according to months (Figure 3.34). The similarity percentage of the monthly distribution patterns can be explained with the aid of dendrogram (Figure 3.35). The result of the dendrogram on group average showed that at the 30 % of similarity level, five groups of nematode species abundance by months had been clustered (which can be visually observed in Figure 3.35). During the 50 % similarity level, the monthly samples can be divided into 11 groups. All the samples were found to be independent (dissimilar to the other months) when reaching the 70 % of similarity (16 groups had been observed according to Figure 3.35).

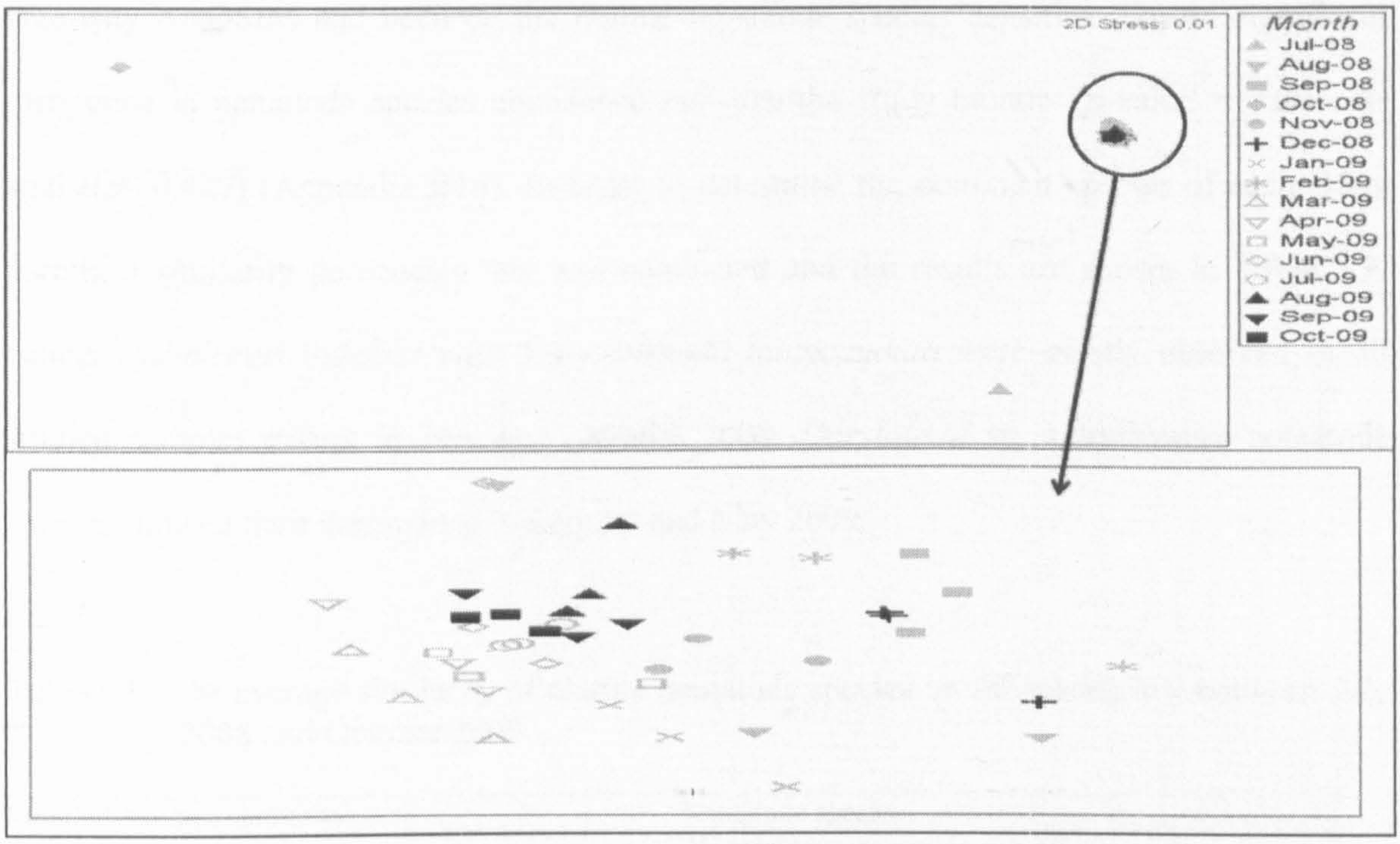

Figure 3.34: Two-dimensional MDS ordination of the similarity matrix constructed from the three replicates density study of each nematode species in the muddy site of Teluk Awar.

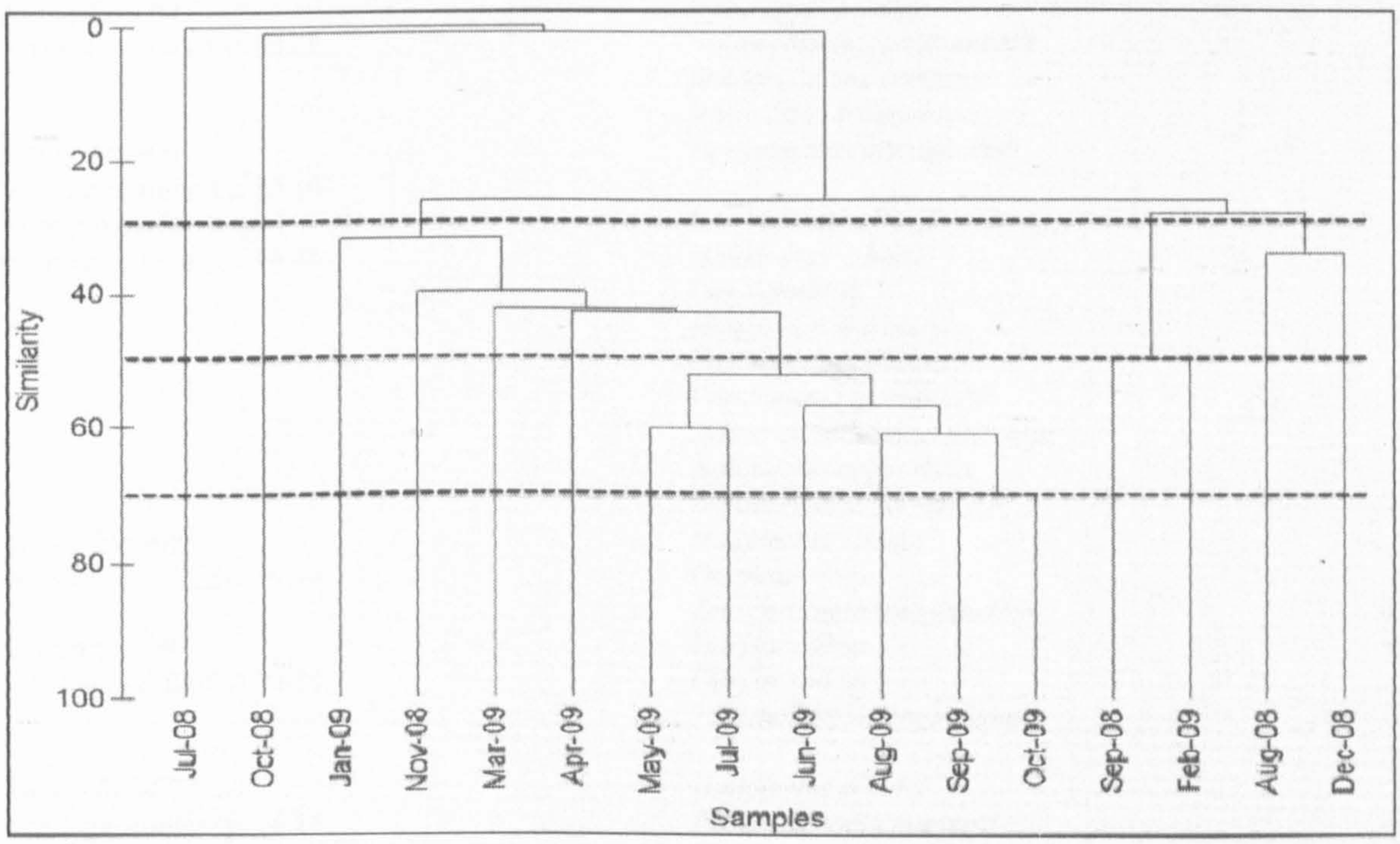

Figure 3.35: Dendrogram produced by Cluster Analysis for seasonal study (muddy site).

One-way ANOSIM had been on the marine nematode species densities showed significant difference in nematode species abundance between the study months (p-value = 0.001; R-statistic= 0.489) (Appendix B16). In order to determine the dominant species of each study month, a similarity percentage test was conducted and the results are shown in Table 3.9. Genus *Haliplectus* together with *Terschellingia longicaudata* were mostly observed in all studied samples except in July and October 2008. *Dorylaimid* sp, a freshwater nematode species showed their dominance in January and May 2009.

Table 3.9: The average similarity of marine nematode species on the muddy site between July 2008 and October 2009.

Months/ Average similarity	Nematode species
Group Jul-08	*Hopperia massiliensis*
Average similarity: 74.60	*Diodontolaimus tunuispiculum*
	Parodontophora pacifica
	Sphaerolaimus islandicus
Group Aug-08	*Haliplectus solicornius*
Average similarity: 14.84	*Dorylaimid* sp 1
	Haliplectus floridanus
Group Sep-08	*Haliplectus schulzi*
Average similarity: 40.28	*Terschellingia longicaudata*
	Sphaerolaimus asetosus
	Haliplectus tripapilatus
Group Oct-08	*Pomponema cotylophorum*
Average similarity: 15.10	
Group Nov-08	*Terschellingia longicaudata*
Average similarity: 46.46	*Haliplectus schulzi*
	Dorylaimid sp 1
	Haliplectus floridanus
	Pomponema coomansi
	Pomponema tautraensis
	Sphaerolaimus macrocirculus
	Haliplectus solicornius
	Metachromadora suecica
Group Dec-08	*Haliplectus schulzi*
Average similarity: 19.74	*Dorylaimid* sp 1
	Terschellingia longicaudata
Group Jan-09	*Dorylaimid* sp 1
Average similarity: 34.81	*Dorylaimid* sp 2
	Terschellingia longicaudata
Group Feb-09	*Haliplectus schulzi*
Average similarity: 16.81	*Procheatosoma martensi*
	Sphaerolaimus macrocirculus
	Terschellingia longicaudata
Group Mar-09	*Haliplectus floridanus*

Average similarity: 32.18	*Dorylaimid* sp 1
	Sphaerolaimus gracilis
Group Apr-09	*Haliplectus floridanus*
Average similarity: 43.17	*Sphaerolaimus macrocirculus*
	Terschellingia longicaudata
	Pomponema coomansi
	Daptonema simplex
Group May-09	*Dorylaimid* sp 1
Average similarity: 41.03	*Sphaerolaimus macrocirculus*
	Terschellingia longicaudata
	Halichoanolaimus dolichurus
Group Jun-09	*Sphaerolaimus macrocirculus*
Average similarity: 22.23	*Haliplectus floridanus*
	Dorylaimid sp 1
	Pomponema coomansi
	Terschellingia longicaudata
Group Jul-09	*Haliplectus floridanus*
Average similarity: 56.34	*Terschellingia longicaudata*
	Dorylaimid sp 1
	Daptonema tenuispiculum
Group Aug-09	*Terschellingia longicaudata*
Average similarity: 47.18	*Daptonema tenuispiculum*
	Sphaerolaimus macrocirculus
	Parodontophora breviseta
Group Sep-09	*Terschellingia longicaudata*
Average similarity: 51.58	*Daptonema tenuispiculum*
	Sphaerolaimus macrocirculus
	Dorylaimid sp 1
	Haliplectus floridanus
Group Oct-09	*Terschellingia longicaudata*
Average similarity: 72.04	*Sphaerolaimus macrocirculus*
	Daptonema tenuispiculum
	Haliplectus floridanus
	Dorylaimid sp 1

A draftman plot on the abiotic and biotic parameters at the station of muddy site showed that the mean temperature and mean chl *a* were left-skewed (Figure 3.36). A Log (V) transformed was conducted on both variables prior subjected to the BioEnv test to prevent skewness. Results of the BioEnv showed that five parameters were positively correlated to the marine nematode species densities (mean pH, Log (Mean temperature), mean TOM and silt & clay) with the correlation value of 0.743) (Appendix C5). However, a lower correlation value was obtained when adding another additional parameter (mean surface temperature) into the analysis (correlation = 0.730) (Appendix C5).

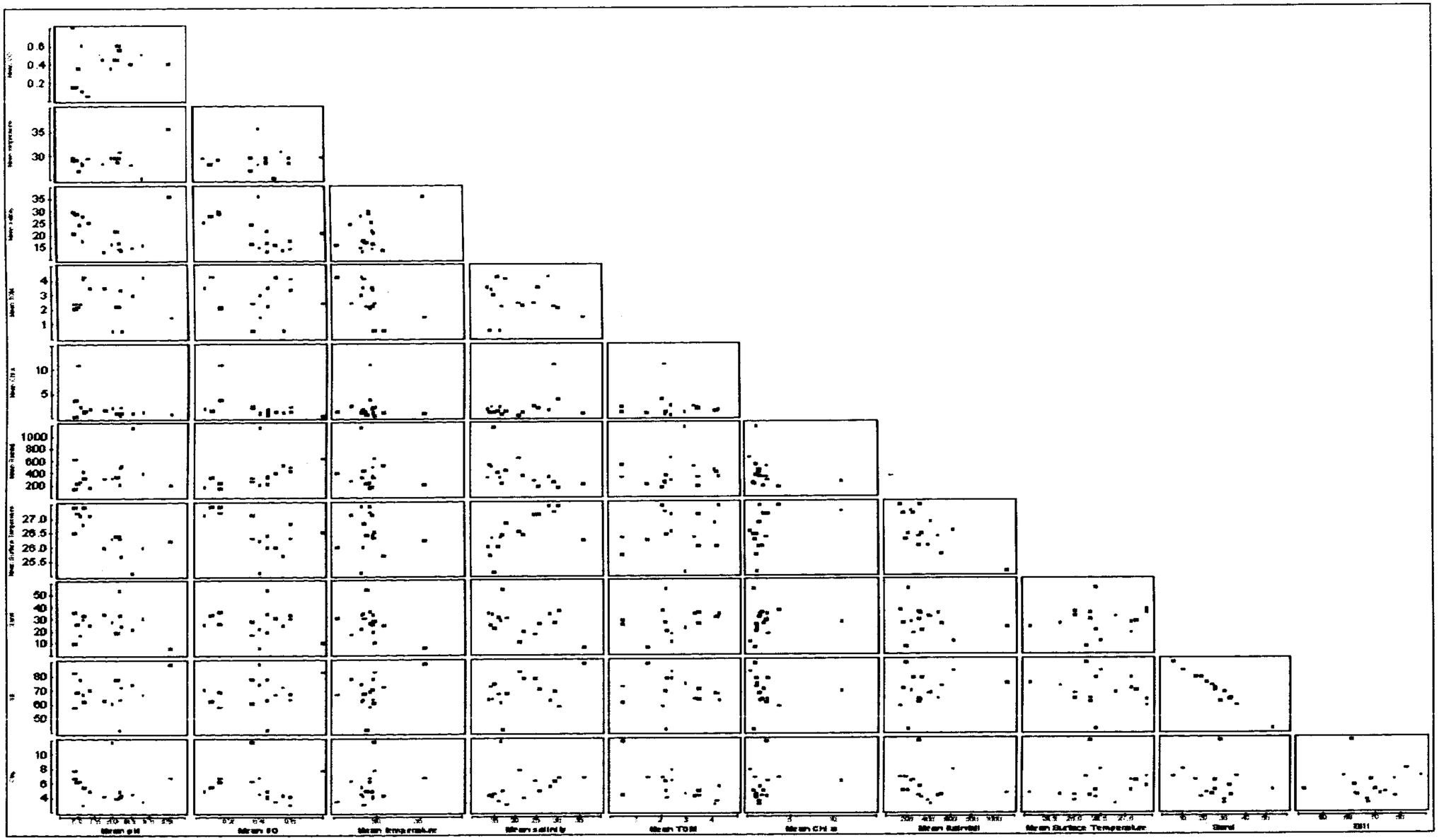

Figure 3.36: Draftman plot from the muddy site's abiotic and biotic parameters.

Detailed FFG of the nematode species together with the mean percentage contribution of each species are listed in Appendix E6. The temporal FFG of the marine nematode is documented in the present study. Principal component analysis showed a clear visual image in determining the FFG of the muddy site (Figure 3.37). FFG of 2A was recorded dominant in July 2008 while October 2008 was dominated by the FFG of 1B. Besides that, all the other 14 months samples were documented to be dominated by the FFG of 1A.

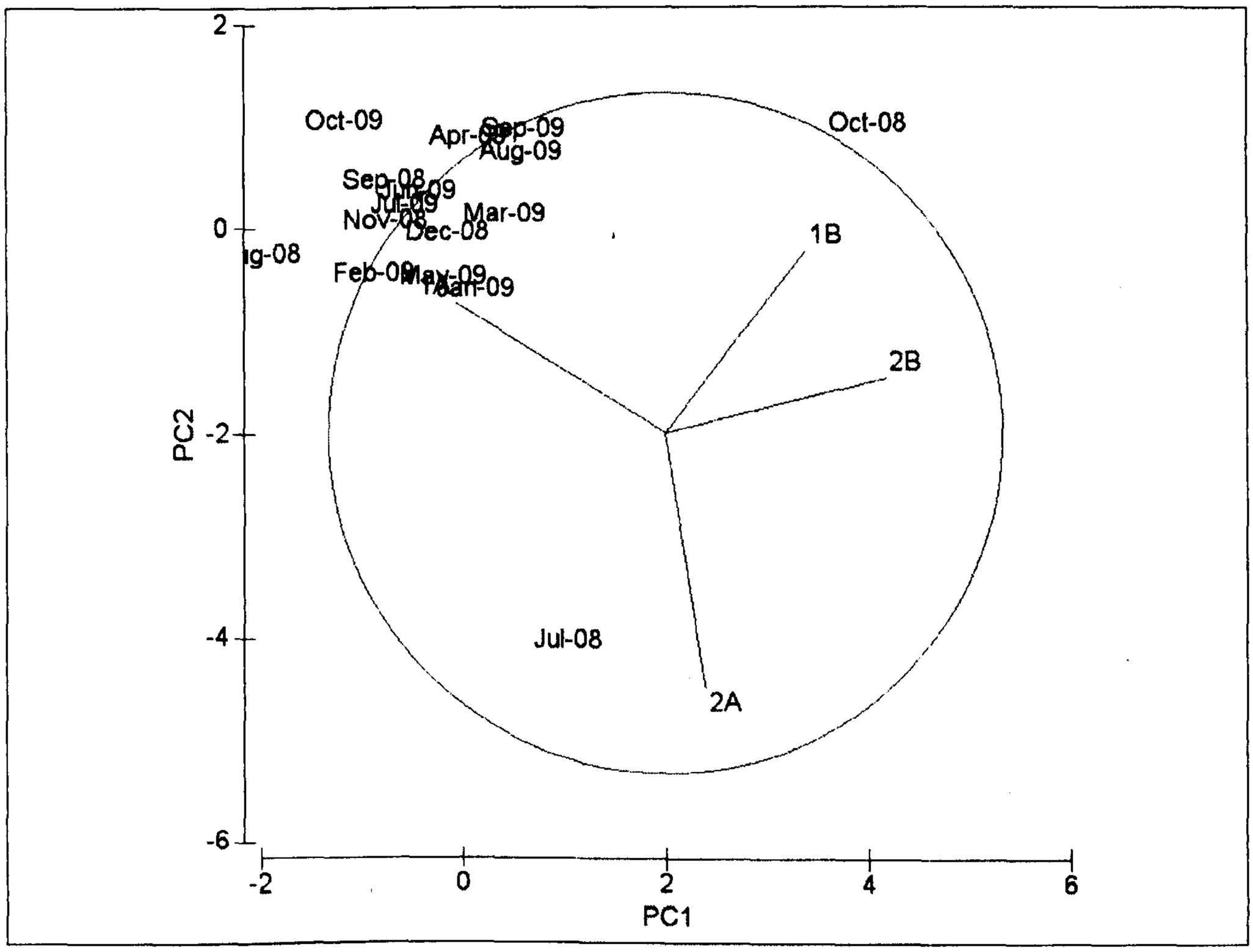

Figure 3.37: Principle component analysis plot derived from the mean percentage contribution of the functional feeding group (FFG) of nematode species from each site and stations (muddy site).

4.0 DISCUSSION

4.1 Coastal study

The present study has documented a total of 30 genera of free-living marine nematodes with a total of 85 species from Sarawak coastal waters (excluding the 1 order that consists of 2 freshwater nematode species). Most of the stations were recorded with the diversity indices value below 2.0 bit/individuals except for Lutong River and Miri Beach. This could be explained by the low sediment quality represented in the result of the diversity index. The Shannon-Weiner diversity index (H') (Shannon and Weaver, 1949) is the most widely used measure of the benthic community diversity (Clarke and Warwick, 1994) indicating sediment condition. According to Lewis (2005), sediment quality is considered poor if the index value was 2.0 or less.

However, Sematan River with index value below 2.0 yet having high nematode density compared to Lutong River which recorded with higher index value. Particle size fractions probably can explain the phenomenon. According to Giere (2009), poorly sorted sediment particles such as the mixing of sand with gravel, silt and clay become tightly packed and the interstitial pore water is often reduced to only 20 % of the total volume (as recorded in Lutong River). The poorly sorted particles fractions contribute to the low DO.

Besides that, the food source availability probably can also explain the phenomenon above. In the study of Montagna (1995) and Moens *et al.* (1999), they determined that nematodes can utilize organic matter in different forms and their density and distribution have been related to the food availability and to the organic matter at the bottom of the sediments. Besides that,

several literatures also mentioned on the density of the nematodes varied considerably both on global and local scales (Dye, 1983; Ólafsson, 1995; Shabdin and Othman, 2008). Mean densities of marine nematode were discovered to be high in Miri beach and Sematan River. Besides that, the species number was recorded to be high in several sites (Miri Beach, Lutong River, Sematan River, Jerijih River and Similajau Beach.). This finding totally matched with the concept that the predominance of sandy sediments contribute to a decrease in density and an increase in diversity (Steyaert *et al.*, 2003; Adâo *et al.*, 2009). All the sites which recorded with higher nematode species were the sandy sediments. The external surface area of the sediment particles is an important determinant of meiobenthos life and it directly defines the area available for the establishment of biofilms (mucus secretions of bacteria, fungi, diatoms, fauna) (Giere, 2009). The larger the surface area, the more microorganisms activities can be carried on. Platt and Warwick (1988) stated that species richness and diversity varies among habitats, being greatest in sandy beaches with over 100 nematode species being typical while in muddy site and in algal communities, the number of species is more typically in the range of 30 - 70.

Several sites recorded with pH above 7. In the present study, the results show that the highest nematode density was recorded in Miri Beach and Sematan River (pH range 7.0-7.7). However, stations such as Engriting Beach, Lutong River, Jerijih River, Tanjung Manis, Kabong River, Tanjung Kembang Beach and Batu Mandi Sematan were all having the pH value within the range but recorded with lower density. This probably indicated that the pH parameter was not the independent factor that influencing the community structure of the marine nematode but the presence of others confounding factors. Several factors had been discussed by the other studies on the decreasing of pH below 7. Low pH reading also been

recorded in anoxic, hydrogen sulfide-containing sediments (Wu, 2002). Besides that, the rise in the CO_2 globally also recorded to increase the acidity of the seawater or the exposure to the anthropogenic pollution (Cai and Riemer, 1993). However, in certain studies, it showed that the eutrophication cause a reduction in oxygen, mostly associated with increases in hydrogen sulfide and ammonia in many areas and the rich content of degradable, oxygen-consuming matter caused problem for the benthic biotopes (Diaz and Rosenberg, 1995; Wu, 2002).

High DO readings had been recorded in all the study sites except for Punang River (lower DO with pH - 6.45). However, the DO in the present study does not show a significant trend in affecting the species composition of the marine nematode. The high DO readings which had been recorded in all sites were due to the location of the sampling sites (marine and estuarine). Statistical analysis of BioEnv showed that the highest positive correlation of the study was 0.311. The low correlation value indicated that abiotic factors were not the significant factors that influent the distribution patterns of the marine nematode assemblages along Sarawak coastal waters but probably by other confounding factors (biotic factors, pollutants or hydrodynamic forces) (Wu, 2002; Shabdin and Othman, 2008; Adão *et al.*, 2009). Mean percentages of the species abundance have been recorded in Appendix E1. The distribution patterns of marine nematodes in the present study do not show any similarity due to the geographical location of the sampling sites (estuarine and marine). The densities of nematodes were recorded to be varied for both on global and local scales (Dye, 1983; Alongi, 1987a; Ólafsson, 1995).

4.2 Horizontal study of marine nematode at Teluk Awar.

Site A of Teluk Awar showed that the marine nematode was highest in station 4. However, the highest abundance of nematode was different in site B (station 1). These findings were contracdited with several authors' finding where the highest abundance of meiofauna was recorded in low tide stations (Hodda and Nicholas, 1986; Alongi, 1990a; 1990b; Sasekumar, 1994). This can be explained by Ólafsson (1995) where the spatial distribution of meiobenthos especially nematodes is notoriously patchy and unpredictably variable. Therefore, it can be concluded that the density of the nematodes in muddy and sandy sediments varied both on global (temperate and tropical) and local scales (Sabah and Sarawak) (Alongi, 1987b; Ólafsson, 1995; Shabdin and Othman, 2008). However, the total densities (ind. /10 cm^2) of nematode recorded in the present study show an extreme low as compared to the similar studies conducted in other tropical and temperate areas (Platt, 1977; Alongi, 1987b; Barnes *et al.*, 2008; Shabdin and Othman, 2008; Hourston *et al.*, 2009). In the study of meiofauna at the southeast coast of India by Chinnadurai and Fernando (2007), the results showed that the marine nematode densities were within the range of 200-850 ind. / cm^2 higher than the results of the present study (0-550 ind. / cm^2).

Alongi (1990b) and Giere (2009) both claimed that the biotic and abiotic factors are contributing to the distribution pattern of the nematode community. A lot of confounding factors can explain the phenomenon (lower density in present study) where the environmental variables such as temperature (Gerlach and Schrage, 1971; Heip *et al.*, 1978; Warwick, 1981; Hourtson *et al.*, 2009), salinity (Moore, 1979; Dye, 1983; Gee and Warwick, 1984; Coull, 1988; Adão *et al.*, 2009), dissolved oxygen (Tietjen, 1969; McLachlan, 1978), particle size

fractions (Capstick, 1959; Teal and Wiser, 1966; Hodda and Nicholas, 1986; Shabdin, 2006a; *Adão et al.*, 2009) and food source availability (Santos *et al.*, 2008) all contribute to the community structure changes of nematode assemblage which possibly explain the phenomenon in the present study.

According to Shabdin and Othman (2008), the distribution patterns of the nematode in Sabah are influenced by the height of the beach support the finding of the present study. Station 8 and 9 (subtidal stations) were recorded with extreme low species number and density compared to the other stations in the intertidal zone (similar environment parameters) even though with higher DO. This phenomenon was probably due to the presence of confounding factor such as the hydrodynamic forces. During the sampling periods at the subtidal stations, the water current was observed to be strong. The high velocity of current during the flood/ebb tide in station 8 and 9 might showed an un-preference habitat for the marine nematodes. These findings matched with Adão *et al.* (2009) where the spatial distribution of the subtidal nematode density and composition reflects both sediment composition and the hydrodynamic conditions.

However, DO is recorded important in contributing to the distribution pattern of marine nematode in site B of the present study. The recorded correlation value was 0.543 after combining with the other three parameters (TOM, salinity and temperature). The current study shows that most of the marine nematode density is highest at the optimum temperature of 33 ^{o}C. When the temperature increased until 35 ^{o}C the densities of the nematode decreased as shown in station B2, B3 and B5. Temperature has a profound effect on minimum generation time T_{min} in all nematode studies (Gerlach and Schrage, 1971; Tietjen and Lee,

1972; Heip *et al.*, 1978; Warwick, 1981). Several authors concluded that the effects of the temperature on the species densities of the nematode are correlated (Platt, 1977; Heip *et.al.* 1985; Gheskiere *et al.*, 2004; Shabdin and Othman, 2005; 2008). Previous studies showed that the nematode activities are influenced by the temperature within the range of 10-35 °C (Wieser, 1953) and Hopper *et al.* (1973) found that temperature within the range of 33–35 °C disturbed the reproduction process of the nematode.

In contrast, site B showed a distinct fluctuation in the nematode densities although having similar TOM compared to site A. Station 2, 3, 4 and 6 of site B were recorded with low nematode density. This shows that the DO contributes to the irregular trend in the present study as low DO is discovered in all the stations mentioned above. Meiobenthic organisms have relatively large surface areas and mostly high oxygen demands; only a few specialized forms will prefer hypoxia conditions and it proves that the distribution of the most meiobenthos communities can be correlated to the oxygen supply of the pore water (Giere, 2009).

Salinity is one of the parameters that can affect the density of the nematodes (Moore, 1979; Dye, 1983; Gee and Warwick, 1984; Coull, 1988; Adão, 2009). The densities of the meiobenthos including the nematodes are found decreased when the salinity of the area is low (Hodda and Nicholas, 1986). In the present study, the salinity is recorded to be low at station 1 for both study sites. The finding was dissimilar with the finding of several authors that higher salinity contributing to higher nematode density especially in a closed coastal lagoons (Hodda and Nicholas, 1986; Barnes *et al.*, 2008). However, Capstick (1959) found that the nematodes had a great toleration with respect to a wide range of salinity supported by the

findings of Gal'tsova and Platonova (1985) that the nematode population can tolerate to the changes of salinity in coastal water. Besides that, the phenomenon in station 1 for both study sites also probably caused by the influx of the freshwater from Sarawak River. The influx of the freshwater from Sarawak River during the low tide (Figure 2.2) probably increased the food source availability at the selected area. The marine nematode community structure at the mesohaline section of the present study is similar to the study of Adâo *et al.* (2009) that having *Daptonema, Sabatieria* as dominant genera together with certain species from the genera of of *Sphaerolaimus, Viscosia, Pomponema*, and *Parodontophora. Dorylaimid* spp from the order of Dorylaimida (freshwater nematode) also been observed to be the dominant species in station 1 of site A. This was due to the exposure of the sampling station to the influx of freshwater from the Sarawak River during ebb tide. Studies on the community structure of the free-living marine nematodes all showed a positive agreement on the influence of salinity (Platt, 1977; Alongi, 1987a, 1987b; Gheskiere *et al.*, 2004; Shabdin and Othman, 2005; 2008; Chinnadurai and Fernando, 2007; Barnes *et al.*, 2008).

The present study sites do not show a distinct sandy or muddy beach. The fractions changed according to zonation when moving outward from mean high water neap (MHWN) to the subtidal stations. Most of the stations in thepresent studies are dominated by the particle size of 63µm (very fine sand) and silt. Several literatures (Steyaert *et al.*, 2003; Adão *et al.*, 2009) had recorded that muddy area consists of lower species number but higher abundance of individual while sandy beaches is dominated by higher number of species. The present horizontal study shows that particle size fractions are not affecting the distribution pattern of marine nematode in site A but oppositely influencing the community structure of marine nematode in site B. This suggested on the presence of certain confounding factor that had

interrupted the natural law of the marine nematode distribution pattern. This is proven in the present study (station 2 of site A) which showed an increasing in the marine nematode abundance and species richness even though recorded with silt fraction. The food source availability was suspected to be the main cause. This phenomenon could be explained by the higher organic matter that had been recorded during the laboratory analysis in station 2 of site A. According to Wieser (1953) and Rzeznik-Orignac *et al.* (2003), a large amount of organic matter decay, anoxic conditions and high bacteria development environment providing food source for certain species of nematodes.

The measurement of TOM in the present study included all sorts of un-digestible organic matter (including food source) similar to the study of Pinto and Bemvenuti (2006). According to Ansari *et al.* (1983), the higher organic input contributes to lower dissolved oxygen of an environment. Present study shows no reverse effects on the DO when the TOM increased. It showed a similar environment characteristic in Skibbe (1991) that recorded with oxygen-saturated sediment although having high organic input. The phenomenon is explained by the presence of hydrodynamic forces. Shabdin (1985) mentioned that the hydrodynamic forces might lead to greater sediment mixing hence increased oxygenation on sandy and muddy areas. Besides that, site characteristics of shallow water bay and wind effects also influenced the oxygen result (Pinto and Bemvenuti, 2006). Station 1, 2 and 3 of site B showed a high reading of organic compound probably related to the vegetation roots and litters contribute by the mangrove species such as the *Avicennia marina*, *Rhizophora mucronata*, *Rhizophora apiculata* and *Casuarina equisetifolia*. The presence of organic matter contributes to the food source for certain genus of marine nematode such as the non-selective deposit feeders (1B) *Daptonema* spp.

The free-living marine nematode species tend to be selective in the food selection and the presence of large amounts of particular food type at a locality would favour colonization by species that belong to a particular trophic group or groups (Hourston *et al.*, 2009). The distribution of the nematode's FFG suggested that most of the nematode assemblages in site A were conquered by the FFG of 1B (non-selective deposit feeder) such as *Daptonema tenuispiculum* reflected the presence of greater amounts markedly contributed by the food availability. Only station 2 of site A was found to be dominated by the marine nematode from the FFG of 2B (predators/omnivores) (*Sphaerolaimus lamasus* and *Viscosia stenolaima*). Subtidal station 9 (site A) was recorded with *Trichotheristus mirabilis* from the 1A (selective-deposit feeder) group. *Daptonema* spp and *Sabatieria* spp which used to be recorded in muddy site (Rzeznik-Orignac *et al.*, 2003) are deviate from the general trend in the present study. The particle size fractions which did not appear to be influecing the nematode densities at Teluk Awar paralleled to the study carried out by Boyd *et al.* (2000). Probably other factors had greater influence on the nematode community structure such as the food availability compared to the particle size. Stations in site B showed a more diverse in the FFG along the transect. In site B, BioEnv demonstated that particle size fraction was one of the component that affect the community structure of the marine nematode. This probably contributed to the diverse of marine nematode species recorded in site B. Several literatures (Warwick, 1971; Conrad, 1976; Shabdin, 2006a) showed that particle fractions affect the diversity of the marine nematodes.

Further analysis in the species abundance and similarity index using the SIMPER test showed that Site A was dominated by the *D. tenuispiculum* followed by *D. hirsutum* while site B was dominated by *D. hirsutum*. *Daptonema tenuispiculum* illustrated a distinction in the

abundance of both study sites (Appendix D1) (10.91 %). According to Schratzberger and Warwick (1999), a mud nematode assemblage was better able to adapt the effects of organic enrichment compared to the sandy nematode assemblage. This finding was agreed by Boyd *et al.* (2000).

Historical studies (Heip *et al.*, 1985; Sommerfield *et al.*, 1995; Boyd *et al.*, 2000) verified that the occurrences of *Daptonema tenuispiculum* is correlated to the food source availability. The adaptive characteristics of *D. tenuispiculum* and the supportive results on the BioEnv where TOM affecting the nematode abundance in both sites may conclude that the marine nematode community structure in Teluk Awar probably count on the food source availability.

Generally, the concept of using the environmental variables in determining the community structure has been well established. BioEnv analysis showed that TOM, salinity, temperature and DO contributed to the nematode community structure in site A of Teluk Awar. Site B was recorded to be influenced by particle size fractions, total organic matter, temperature and DO.

4.3 Vertical Profile of Marine Nematode at Teluk Awar

An organism's distribution and abundance patterns of the meiobenthos often related to the habitat heterogeneity (Woodin, 1981; Pinto *et al.*, 2006) or the resource patchiness and anthropogenic disturbance. Although the current vertical profiling show not much comparison in marine nematode assemblages across sediment depths yet several trends are observed. The present study focuses in determining the distribution pattern of marine nematode species at the selected depths and also the tolerance of the specific marine nematodes in different sediment depths of Teluk Awar. In most of the studies, the marine nematodes are found dominantly inhabit at the 3 cm uppermost of the sediments (Kotwicki *et al.*, 2005; Pinto *et al.*, 2006).

The effects of temperature on the marine nematode community structure had been recorded to influence the vertical occurrences of the meiobenthos such as the upward nearer to the surface during the summer but migrate further down during winter (Giere, 2009). The natural vertical migration behaviour of the marine nematodes in temperate countries probably due to the minimum generation time which had been proven by the studies of several authors (Tietjen and Lee, 1972; Heip *et al.*, 1978; Warwick, 1981). In tropical country such as Malaysia, it is believed that the temperature only slightly affected the vertical distribution of the marine nematode community. The absence of the four seasonal variations denied the direct influence of temperature on marine nematodes in tropical country such as Malaysia. When comes to the influence of the monsoon season in Malaysia, the dropping of temperature mostly due to the heavy rainfall. Salinity and hydrodynamic force are suspected to priory affecting the marine nematode community structure.

The vertical distribution of meiobenthos especially nematodes in sediments had attracted much attention since the development of the sulphide system concept. Sandy bottoms that are typically yellowish in colour, positive values of redox potential are obtained throughout, while in soft muds with rich organic content, the grey-to-black layers underneath a thick brighter surface will yield clearly negative redox potential values (Giere, 2009). Study of Kotwicki *et al.* (2005) believed that the vertical zonation is generally controlled by the position of the Redox Potential Discontinuity (RPD) layer and it supports the findings of Coull (1988) and Steyaert and Vincx (1996). The findings are paralled with the observation of the present study. In the present study, marine nematodes are obtained in deeper layers (6 - 15 cm) of site A compared to site B where zero nematode was rocorded. This probably due to the influenced of RPD layer. A wide and diffuse transition from bright over gray to black indicates the gradual disapearance of free oxygen to a layer with oxidized compounds (without free oxygen) (Giere, 2009).

McLachlan (1977) suggested that the meiofauna mostly recorded in conditions where oxygen is plentiful but also escaped from desiccation and also the feeding activity which affect the vertical distribution. The later is confirmed by the result of the present study. According to the ANOSIM and SIMPER test that had been carried out, the results proven that FFG affecting the vertical distribution of marine nematode in Teluk Awar which was confirmed by the studies of Steyaert *et al.* (2001, 2003). The vertical distribution of this species into the sediment seems to be dependent on food availability rather than oxygen concentrations (Steyaert *et al.*, 1999). Marine nematode of FFG 1B (non-selective feeder), 2B (predators/omnivores) and 2A (epigrowth or diatom feeders) are dominantly found at the

upper 5 cm of the samples in the present study. This probably due to the food source availability.

Examples of 1B species observed in the present study are *Daptonema* spp and *Sabatieria* spp. These species are the most famous genera and categorized as eurytopic species which dominantly observed at the upper 5 cm layer. The present study suggests that the *Daptonema* spp such as *D. hirsutum* and *D. tenuispiculum* are typical surface dwellers which are not affected by the redox state, equivalent to the study of Steyaert *et al.* (1999). *Daptonema tenuispiculum* was previously recorded to be a successful migrator, reached higher values in a microcosm study of Schratzberger *et al.* (2002). Only a small amount of *D. tenuispiculum*, *Daptonema setifer*, *Stylotheristus mutila* and *Procamacolaimus acer* are determined at deeper layers in the present studies. This probably caused by the hydrodynamic forces where the mixing of the sediments affected the vertical profiling of certain species.

Historical studies (Warwick and Gee, 1984; Steyaert *et al.*, 1999) on the *Sabatieria* spp proved that the distribution pattern of *Sabatieria* occurred on the surface or 4-6 cm depth. It is well-known that some *Sabatieria* species often associate with reduced condition, even though in a very low oxygen concentrations or anoxic conditions (Jensen, 1983). *Sphaerolaimus* spp, *Hopperia* spp, *Parodontophora* spp, *Belbolla* spp and *Viscosia* spp were also recorded at the upper 5 cm layer together with the other dominant FFG of marine nematode. This explained that the predatory activity and the competition for food affecting the vertical distribution pattern in Teluk Awar.

Viscosia poseidonica, Viscosia stenolaima, Viscosia isotonchula and *Viscosia separabilis* from the FFG of 2B are found below the 5 cm layer of the present study. *Pomponema polydonta, Pomponema tesselatum* and *Sphaerolaimus islandicus* (FFG of 2B) are also recorded in deeper layers of the present study. According to Heip *et al.* (1985), in natural conditions *Viscosia* spp is a surface dweller. This phenomenon probably can be explained by the study of Pinto *et al.* (2006), which showed that predators such as *Viscosia* spp and *Parodontophora* spp were recorded in a deeper layers and may be attracted by higher prey availability as a consequence of *Laeonereis acuta* (deposit-feeding polychaete) activities.

Results of the present vertical study were analogous to the study in Lok Kawi, Sabah (Shabdin and Othman, 1999). Both studies show that most of the marine nematodes record near to the surface layer except for a minor group of selected species. The availability of food (benthic diatom and other algae) at the upper 5 cm in the present study indicate that chl *a* might be the profounding factor contribute to the presence of epigrowth feeders (*Hopperia* spp and *Belbolla* spp). According to Kotwicki *et al.* (2005), predation and competition for food might be important for the zonation of meiofauna on beaches.

4.4 Seasonal study of marine nematode community structure in Teluk Awar

The coastal areas of Sarawak experience a rainfall regime of one maximum and one minimum. The maximum rainfall occurs during January. In the coastal areas of Sarawak, the minimum rainfall occurs in June or July. Under this regime, most of the rainfall is received during the northeast monsoon months of December to March. In fact, it accounts for more than half of the annual rainfall received on the western part of Sarawak (Malaysian Meteorological Department, 2010). The monthly mean surface temperature and mean rainfall data was obtained from the Sarawak Meteorology Centre.

4.4.1 Sandy site

The *in situ* pore water temperature in the current study shows an emblematic trend in the tropical waters such as Sabah (Shabdin and Othman, 2005). Higher readings were recorded in October and November 2008 (36.1°C; 37.82°C). The high temperature readings in the present study are probably due to the duration of exposure (the sandy beach) to the sunlight after the ebb tide. The DO readings of the pore water in the present study are low due to the less contact of the water with the atmosphere analogous to the study of Shabdin and Othman (2005) in Sabah. The pH of the study site was not influenced by the seasonal heavy rainfall yet showed a declining since March 2009. In July 2008, the study area was not recorded with any mangrove plant species. However, a re-plantation project had been carried out by the Sarawak Forestry Department since the end of February 2009. The project covered an area of 25 hectare and three mangrove species had been re-planted: Bakau kurap (*Rhizophora mucronata*), Bakau minyak (*Rhizophora apiculata*) and Rhu laut (*Casuarina equisetifolia*). The re-planted pattern was 2 m x 2 m distance and the project covered the present study site.

The re-plantation project which had been carried probably contributed to the decrease of the pH since March 2009 compared to the earlier studied months. The phenomenon can be explained by the leaf litter from the re-planted trees which increase the bacterial degrading process or certain "antropogenic" activities (waste disposal). Several authors had proven the relationship between the pH and the microbial degradation of leaf litter (Sjörs, 1959; Chamier, 2004). The disturbance caused during the mangrove re-plantation probably also explained the decreasing of marine nematode density in March 2009.

The lowest salinity reading was recorded in January 2009 due to the heavy rainfall. TOM readings showed higher concentration of organic matter during mid-year. Higher organic matter compound was determined in July - October 2009 compared to the same months in 2008. This probably caused by the leaf litter from the re-planted mangrove trees which increased the organic compound of the studied sediments. Higher chl *a* had been observed in November 2008, January 2009, May 2009 and August 2009. In comparison to the physico-chemical data, the results of the present study did not show a specific trend contribute to the sudden bloom of the chl *a* as mentioned earlier. The presence of the other confounding factor such as the influx of high nutrient content from Sarawak River in selected months (November 2008, January 2009, May 2009 and August 2009) contribute to the sudden bloom of microalgae. Eventhough the present study lacks of laboratory studies on the nutrient level of water and sediment quality, yet several studies had shown the linkage between nutrient and chl concentration (Brunsen *et al.*, 1994; Foster *et al.*, 1997). In addition, the monthly mean surface temperature shows that the sampling period of the present study is coincided with the August 2009 – January 2010 El Niño event. The mean surface temperature of the study site showed an increasing of 1°C since August 2009 compared the monthly mean surface

temperature recorded in 2008. Several studies had shown the disturbance of El Niño events on the marine invertebrates (Grant *et al.*, 2000; Guzmán del Próo *et al.*, 2003)

The marine nematode densities of the present study are low and similar with a study carried out at an intertidal sand-flat in the Weser estuary, Germany (Skoolmun and Gerlach, 1971). The mean densities of the present study are recorded to be influenced by the seasonal rainfall. During the dry season (July – October 2008/09), the marine nematode densities were recorded to be the highest and drastically dropped during the wet season (raining season). Low densities were recorded since November 2008 to March 2009. However, the comparison on the abundance between the dry season of the two study years (2008 and 2009) must not be out looked. It showed that even though the nematode densities yet to be the highest during the dry season of 2009 but lower if compared to the equal month in 2008. This probably was caused by the El Niño event where the monthly mean surface temperature increased (+1^{o}C). The sudden increase of temperature might shock the community structure of marine nematode.

Vertical migration to avoid the sudden changes of temperature might explain the reduction of marine nematode densities in the present study. The migration pattern is recorded as an adaptive mechanism (Alongi, 1990b; Shabdin and Othman, 2005; Giere, 2009). Certain species are recorded to migrate deeper into the sediment avoiding the stressed environment. Pinto *et al.* (2006) showed that facultative predators such as *Viscosia* spp and *Parodontophora* spp were recorded to migrate into deeper layers due to the attraction of higher prey availability. Further microcosm studies are needed to prove the assumption.

Temperature and food source are the most obvious factors explaining the changes of density. Nematodes had been categorized into different FFG and the changes of community structure are known to be correlated with the availability of different food items (Heip *et al.*, 1985). Several authors studied the relationships between environmental variables and the trophic structure (Wieser, 1953; Warwick and Buchnann, 1970; Boucher, 1980; Alongi, 1990c) found that the changes of feeding pattern of marine nematode (as recorded) to be different temporal period. According to Pavlyuk (2000), the seasonal changes in the nematode population density are closely related with the changes of the diet.

The species distribution of the present study can be divided into three distinct groups. *Halichoanolaimus ovalis, Viscosia* spp, *Sphaerolaimus* spp which are categorized in FFG of 2B (predators/omnivores) are highly recorded together with *Parodontophora pacifica* (FFG = 2A) during the dry season for 2008/09. October 2008, which was recorded to be the interval between the dry and wet season, a different pattern of marine nematode community was observed. *Spririnia parasitifra* (FFG =2A), *Haliplectus floridanus, Terschellingia longicaudata* and *Wieseria longicaudata* (FFG =1A) had been recorded during the selected month besides the other species mentioned earlier. Lower organic matter compound together with a sudden bloom of chl *a* concentration probably explain the phenomenon. The total organic content was recorded to decrease from September 2008 to October 2009. The increase of nematode under the FFG of 1A in the present study can be explained by the study of Rzeznik-Orignac *et al.* (2003) where organic matter results in the organic matter decay, anoxic condition and bacteria development. *Terschellingia longicaudata* was recorded to be found in anoxic condition and feeds on bacteria (Wieser, 1953). Higher chl *a* contributes to the food source availability enhance the FFG of 2A species such as *Spirinia parasitifera* and

others. In the seasonal study carried out by Yodnarasri *et al.* (2008), the results showed that after the high concentration period of chl *a*, epigrowth feeders increased. Besides that, Montagna *et al.* (1995) also suggested that the marine nematode grazing rate did increase with the increasing micro-phytobenthos production in the sediment. However, the chl *a* concentration in the current study is recorded only correlated with certain species similar to the study of Shabdin and Othman (2005). During the bloom of chl *a* in August 2009, *D. tenuispciculum* was observed to increase. Seasonal rainfall pattern was determined to be triumph over the influence of the chl *a* concentration on the marine nematode abundance in Teluk Awar. This can be explained by the phenomenon where higher chl *a* concentrations were recorded during the raining season yet the nematode densities decreased. This indicated that the changes of the abiotic parameters (salinity, temperatures and also the particle fractions) during the raining season influent the distribution pattern of the marine nematode rather than chl *a*.

Rzeznik-Orignac *et al.* (2003) noted that the variations in the marine nematode abundance reflect the different trophic requirement over the year where selective (1A) and non-selective deposit feeder (1B) were abundant during autum and winter comparable to the result of the present study. The present study shows that *D. hirsutum* (FFG of 1B) was dominant during the wet season (November 2008-April 2009) accompanied by the predator/omnivores species such as *Viscosia* spp, *Sphaerolaimus* spp and *Parodontophora* spp. After the interval of May and June 2009, *Halichoanolaimus ovalis* was recorded to be the dominant species. Study in China by Liu *et al.* (2008) mentioned that epistrate feeders are dominant in the sandy substrates where the predators/omnivores are the least abundant component do not supported the result of present study. In tropical country such as Malaysia, the marine nematode from

the FFG of 2B (predator/omnivores) are dominant during the dry season while non-selective deposit feeders are the dominant species in the sandy substrates during the wet season.

The result of the BioEnv showed that the mean DO, temperature, salinity and particle size fractions are correlated with the marine nematode abundance in the present study. All of the physico-chemical parameters mentioned above showed difference during the wet and dry season. Studies carried out by Pavlyuk (2000), Liu *et al.* (2008), Armenteros *et al.* (2009) and Hourston *et al.* (2009) mentioned that the seasonal study of marine nematode is also correlated with the particle size fractions. The particle fractions in the present study are recorded having a higher percentage of silt in July 2008 where the mean density of marine nematode is also recorded to be low. This phenomenon can be clarified by the finding of Urban-Malinga *et al.* (2006) that more species would be present in a habitat when the silt-clay content decreased and the grain-size increased.

4.4.2 Muddy site

One of the most characteristic, biological rich and ecologically important habitats of the tropics is the mangrove area and it has attracted studies on the meiofauna especially the nematode. The pH value of the muddy site (mangrove area) showed on three different patterns throughout the sampling months. July 2008 was recorded to be having the highest pH value (9.59). This probably can be explained by the intensive assimilation of the abundance of microalgae in the surface layers of the tidal flats which potentially increased the pore water pH to >9 (Giere, 2009). The slight alkalinity of seawater (pH 7.5 - 8.5) makes it well buffered against pH fluctuations. Since April 2009, the pH was recorded to drop from 7.78 to 6.92. According to Giere (2009), the dropping of pH to acidic level probably caused by the anoxic,

hydrogen sulfide containing sediments. However, the recorded pH dropping period maybe correlated with the mangrove re-plantation projects by the disturbance of "anthropogenic" activities (waste disposal).

The DO concentrations are recorded to be low all over the year in a muddy site. This is similar with the study carried out by Shabdin and Othman (2005) where the sediment in the muddy area contained more than 32 % silt and clay and compact below 2 cm depth. It is also believed that the presence of the mangrove trees in the muddy area acted as a buffer zone and reduces the hydrodynamic forces in sediment mixing during the tidal period compared to the sandy site. The fluctuation of the mean temperature and salinity are suspected to be influenced by the rainfall or the influx of the freshwater from Sarawak River. In general, mangrove sediments consist of fine mud that is rich in organic matter. This is proven in the present study where higher TOM readings are recorded in the muddy sediment during the laboratory analysis compared to sandy sediment. The rooting systems and leaf litters of the mangrove trees contribute to the higher organic compounds (Giere, 2009). Chl *a* in the muddy site is overall lower compared to the sandy probably due to the less sunlight penetration caused by the canopy of mangrove trees. However, a sudden bloom of chl *a* concentration occurred in August 2009 probably due to the increased on temperature during the El Niño 2009 - 2010 period.

The distribution pattern of marine nematode (muddy site) in the present study is influenced by the seasonal rainfall and also the changes of climate temperature (mean surface temperature) which is similar to sandy site. However, the result of the present seasonal study shows a dissimilar pattern of densities' distribution. The highest density of marine nematode is

discovered during the interval of dry and wet season (November 2008 and October 2009). The increase of mean surface temperature (+1°C) during the El Niño event of 2009-2010 showed that the mean density of the marine nematode in the muddy site increased spontaneously from August to October 2009. Besides the concept of temperature has a profound effect on minimum generation time T_{min} in all nematodes studied (Gerlach and Schrage, 1971; Heip *et al.*, 1978; Warwick, 1981), the food availability probably also contribute to the phenomenon of the present study. The chl *a* concentration in the present study is recorded to increase drastically in August 2009 and might contribute as food source for certain FFG of marine nematodes. This was also been recorded in the study of Yodnarasri *et al.* (2008) that after a high concentration of chl *a* concentration (June 2003), the density of the nematodes increase.

The trophic structure (or FFG) of the marine nematode was well documented to be different in temporal studies (Nicholas, 2001; Pavlyuk, 2000; Shabdin and Othman, 2005; Liu *et al.*, Yodnarasri *et al.*, 2008; Hourtson *et al.*, 2009). In July 2008, the species abundance of the marine nematode was recorded to be dominated by the feeding type of 2A (epigrowth or diatom feeders) and 2B (predators/omnivores). Recorded species were *Hopperia massiliensis, Diodontolaimus tenuispiculum, Parodontophora pacifica* and *Sphaerolaimus islandicus.* Marine nematode from the FFG of 2A is not discovered in any other months in the present study except for July 2008. This finding can be explained by the patchiness problem in the meiobenthos especially nematode study. Patchiness of the nematodes might be influence by the minute habitat heterogeneities, temporal variations and food web interaction (Warwick *et al.*, 1990). Findlay (1981) studied the patchiness of nematodes discovered some patchiness in total number on a scale of 5 cm^2 but did not focused on the individual species. Schratzberger *et al.* (2002) mentioned that small oscillations reduce the intensity of competitive

displacement and also tent to enhance diversity while severe disturbances negatively affect diversity.

Marine nematode from the FFG of 1A (selective deposit feeders) from the genera of *Haliplectus* (*H. solicornius, H. schulzi, H. floridanus*) and *Terschellingia* (*T. longicaudata*) were documented to be the dominant species throughout the year of the muddy site (mangrove area) in Teluk Awar. A strong correlation of *T. longicaudata* with the organic matter from the study of Rzeznik-Orignac *et al.* (2003) suggested an environmental relation between the two. According to Rzeznik-Orignac *et al.* (2003), *T. longicaudata* is observed to be in a large amount of organic matter decay, anoxic conditions and high bacteria development environment. During the sampling period, black layer was observed under a few millimeters from the surface layer. RPD might be one of the explanations of the species dominancy. The RPD refers to wide and difuse transition from bright over gray to black indicates the gradual disapearance of free oxygen to a layer with oxidized compounds (without free oxygen) (Giere, 2009).

Predators/omnivores (2B) such as *Sphaerolaimus* spp and *Pomponema* spp were observed throughout the years but in lower densities. *Pomponema cotylophorum* was discovered to be dominant in October 2008 probably due to the food availability. According to Santos *et al.* (2008), the nematodes's response to food availability and quality as well as other environmental factors are highly species-specific. The food availability and quality are important factors driving the strong heterogeneous small scale spatial distribution observed in the nematode communities (Moens *et al.*, 1999; 2002). In January 2009 where the highest rainfall is recorded, the freshwater nematode *Dorylaimid* spp were recorded to be dominant.

This probably due to the decreased of the salinity throughout the raining season and depressed the abundant of the other marine nematode species. Studies on the community structure of the free-living marine nematodes showed a positive agreement on the influence of salinity (Platt, 1977; Alongi, 1987b; Gheskiere *et al.*, 2004; Shabdin and Othman, 2005; 2008; Chinnadurai and Fernando, 2007; Barnes *et al.*, 2008) where the species densities decrease followed by the reduction of salinity.

During the bloom of microalgae in August 2009, *D. tenuispciculum* started to occurr in July 2009's samples. The abundant of *D. tenuispiculum* started to increase in the later months' samples. In the present study, chl *a* (which represents the benthic microalgae) is suspected to be the food source for the marine nematodes. *Daptonema* spp, initially classified as a non-selective deposit feeder is able to swallow particles of different sizes and large frustules of diatoms (Boucher, 1974; Jensen, 1979; Rzeznik-Orignac *et al.*, 2003). According to Moens and Vincx (1997), diatoms are clearly an important food since freshly sampled individual of *Daptonema setosum*, commonly have up to 40 or more diatom frustules in their intestine.

The discussions above on the correlations of the biotic and abiotic parameters to the marine nematode community structure of the present study are backed up by statistical results of the BioEnv. The results showed that the mean pH, Log (Mean temperature), mean TOM, silt and clay are correlated with the species abundance in the study of marine nematode in the muddy site (mangrove area) of Teluk Awar. Once again the result of the present study showed a contrast with the review point mentioned in Liu *et al.* (2008) that the muddy site is generally occupied by the non-selective deposit feeders.

5.0 CONCLUSIONS AND RECOMMENDATION

The survey of the marine nematode along the Sarawak coastal waters recorded with the occurrence of 85 marine nematode species from 30 genera. Particle size fractions (sand and silt), pH and dissolved oxygen are found to affect the community structure of the marine nematode from Sarawak coastal waters. The marine nematode assemblages in Sarawak coastal waters were recorded within the range of 0- 700 ind. / cm^2.

The horizontal study at Teluk Awar concludes that the food source availability is the main factor with the aid of several environmental factors such as: salinity, temperature and DO contribute to the structuring of marine nematode community (species richness and evenness). However, the densities of the nematodes in muddy and sandy sediments are concluded to be varied both on global and local scales.

In spite on the abiotic factors (RPD, temperature, particle size and DO), food source availability is also recorded to be influencing the vertical profiling of marine nematode assemblages in Teluk Awar. Certain stress tolerance marine nematode species such as *Viscosia poseidonica, Viscosia stenolaima, Viscosia isotonchula* and *Viscosia separabilis* are recorded in deeper layer of the present study.

The seasonal study showed that the marine nematode community structure not only affected by the particle size fractions (sandy/muddy) but also seasonal rainfall. Community structure of marine nematode in sandy site of Teluk Awar is influenced by abiotic factors (DO, temperature, salinity and particle size fractions) and biotic factors (chl *a*, and TOM). Besides

that, the present study also determines a seasonal pattern in species distribution based on FFG. During dry season in each year (June-October) the beach is dominated by the predator species (2B) and epigrowth or diatom feeders such as *Halichoanolaimus ovalis* (2B), *Sphaerolaimus* spp (2B), *Viscosia* spp (2B) and *Parodontophora* spp (2A). However, during the wet season (November–April), the beach is dominated by the non-selective deposit feeders (1B) such as *Daptonema hirsutum* together with the predatory species (lower density) mentioned during the dry season.

Different seasonal pattern of nematode abundance is recorded in the muddy site. Higher abundance is recorded during the interval of dry and wet season in the muddy site (mangrove area) of Teluk Awar while the peak was recorded during the dry season in sandy beach. Selective deposit feeders (*Haliplectus* spp and *Terschellingia longicaudata*) are recorded to be dominant throughout the year in the mangrove area of Teluk Awar accompanied by *D. tenuispiculum* (non-selective deposit feeders) and *Sphaerolaimus* spp (predators). The findings of the present study represent the spatial distribution pattern of marine nematode in a tropical country such as Malaysia.

Further studies are crucial to be carried out in future to expand the field of interest in nematology of a tropical country such as Malaysia. The future approaches should not only covered the ecological studies (field sampling) but also concentrate on the studies such as the generation time in relation to the changing of the environment together with the feeding and gut content analysis (food dependant and selectivity).

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APPENDIX

Appendix A1: Results of the One-way ANOVA on environmental parameters for Sarawak coastal waters.

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.836	19	.518	189.631	.000
Within Groups	.109	40	.003		
Total	9.945	59			

ANOVA

DO

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	538.726	19	28.354	219.009	.000
Within Groups	5.179	40	.129		
Total	543.905	59			

ANOVA

Temperature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	368.201	19	19.379	1661.056	.000
Within Groups	.467	40	.012		
Total	368.667	59			

ANOVA

Salinity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1397.900	19	73.574	43.068	.000
Within Groups	68.333	40	1.708		
Total	1466.233	59			

Appendix A2: The result on the environmental data of One-way ANOVA for site A (horizontal study).

ANOVA

Salinity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	778.444	8	97.306	1751.500	.000
Within Groups	.500	9	.056		
Total	778.944	17			

ANOVA

Temperature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	54.941	8	6.868	184.202	.000
Within Groups	.336	9	.037		
Total	55.277	17			

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.162	8	.145	11.358	.001
Within Groups	.115	9	.013		
Total	1.277	17			

ANOVA

DO

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23.763	8	2.970	218.584	.000
Within Groups	.122	9	.014		
Total	23.885	17			

ANOVA

Chlophylla

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19.952	8	2.494	5.153	.012
Within Groups	4.356	9	.484		
Total	24.308	17			

ANOVA

TOM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.030	8	.379	24.151	.000
Within Groups	.141	9	.016		
Total	3.171	17			

Appendix A3: The result on the environmental data of One-way ANOVA for site B (horizontal study).

ANOVA

Salinity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1193.111	8	149.139	2684.500	.000
Within Groups	.500	9	.056		
Total	1193.611	17			

ANOVA

Temperature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	81.678	8	10.210	4736.504	.000
Within Groups	.019	9	.002		
Total	81.698	17			

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.957	8	.120	24.004	.000
Within Groups	.045	9	.005		
Total	1.002	17			

ANOVA

DO

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	37.216	8	4.652	2897.439	.000
Within Groups	.014	9	.002		
Total	37.230	17			

ANOVA

Chlophylla

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.925	8	.491	2.751	.076
Within Groups	1.605	9	.178		
Total	5.530	17			

ANOVA

TOM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.984	8	.123	2.512	.096
Within Groups	.441	9	.049		
Total	1.425	17			

Appendix A4: Results of the One-way ANOVA on environmental parameters for Teluk Awar vertical study (site A).

ANOVA

Chlophylla

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.500	6	.417	5.821	.018
Within Groups	.501	7	.072		
Total	3.001	13			

ANOVA

DO

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.816	6	1.636	94.295	.000
Within Groups	.121	7	.017		
Total	9.938	13			

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.005	6	.167	22.094	.000
Within Groups	.053	7	.008		
Total	1.058	13			

ANOVA

Salinity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	743.857	6	123.976	1735.667	.000
Within Groups	.500	7	.071		
Total	744.357	13			

ANOVA

Temperature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	22.454	6	3.742	102.531	.000
Within Groups	.256	7	.037		
Total	22.710	13			

ANOVA

TOM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.022	6	.337	26.966	.000
Within Groups	.088	7	.013		
Total	2.110	13			

Appendix A5: Results of the One-way ANOVA on environmental parameters for Teluk Awar vertical study (site B).

ANOVA

Chlophylla

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.368	6	.561	2.450	.133
Within Groups	1.604	7	.229		
Total	4.972	13			

ANOVA

DO

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.370	6	2.395	1164.259	.000
Within Groups	.014	7	.002		
Total	14.385	13			

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.766	6	.128	20.147	.000
Within Groups	.044	7	.006		
Total	.810	13			

ANOVA

Salinity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1188.714	6	198.119	2773.667	.000
Within Groups	.500	7	.071		
Total	1189.214	13			

ANOVA

Temperature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.204	6	2.201	794.077	.000
Within Groups	.019	7	.003		
Total	13.224	13			

ANOVA

TOM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.747	6	.124	15.384	.001
Within Groups	.057	7	.008		
Total	.804	13			

Appendix A6: Results of the One-way ANOVA on environmental parameters for Teluk Awar seasonal study (sandy site).

ANOVA

DO

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.621	15	.175	7.663	.000
Within Groups	.365	16	.023		
Total	2.986	31			

ANOVA

Salnity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	585.719	15	39.048	416.511	.000
Within Groups	1.500	16	.094		
Total	587.219	31			

ANOVA

Temperature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	356.547	15	23.770	356.453	.000
Within Groups	1.067	16	.067		
Total	357.614	31			

ANOVA

TOM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.901	15	.527	16.361	.000
Within Groups	.515	16	.032		
Total	8.416	31			

ANOVA

chla

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	329.985	15	21.999	2.401	.046
Within Groups	146.584	16	9.162		
Total	476.569	31			

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.673	15	1.245	53.853	.000
Within Groups	.370	16	.023		
Total	19.043	31			

Appendix A7: Results of the One-way ANOVA on environmental parameters for Teluk Awar seasonal study (muddy site).

ANOVA

Chla

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	186.338	15	12.423	4.376	.003
Within Groups	45.416	16	2.838		
Total	231.754	31			

ANOVA

DO

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.245	15	.083	3.278	.012
Within Groups	.405	16	.025		
Total	1.650	31			

ANOVA

pH

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.168	15	1.211	101.808	.000
Within Groups	.190	16	.012		
Total	18.358	31			

ANOVA

Salinity

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1409.969	15	93.998	120.317	.000
Within Groups	12.500	16	.781		
Total	1422.469	31			

ANOVA

Temperature

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	134.490	15	8.966	279.071	.000
Within Groups	.514	16	.032		
Total	135.004	31			

ANOVA

TOM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41.874	15	2.792	31.193	.000
Within Groups	1.432	16	.089		
Total	43.306	31			

Appendix B1: Result of the one-way ANOSIM on the marine nematode assemblages between sites (Sarawak coastal waters).

```
Sample statistic (Global R): 0.813
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0
```

Appendix B2: Result of the one-way ANOSIM on the particle size component between sites (Teluk Awar horizontal study).

```
Sample statistic (Global R): -0.069
Significance level of sample statistic: 89.9%
Number of permutations: 999 (Random sample from 24310)
Number of permuted statistics greater than or equal to Global R: 898
```

Appendix B3: Result of the one-way ANOSIM on the particle size component among stations (Teluk Awar horizontal study).

```
Sample statistic (Global R): 0.349
Significance level of sample statistic: 2.5%
Number of permutations: 999 (Random sample from 34459425)
Number of permuted statistics greater than or equal to Global R: 24
```

Appendix B4: Result of the one-way ANOSIM on the environmental parameters among stations (Teluk Awar horizontal study).

```
Sample statistic (Global R): 0.344
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from 34459425)
Number of permuted statistics greater than or equal to Global R: 0
```

Appendix B5: Result of the one-way ANOSIM on the environmental parameters between sites (Teluk Awar horizontal study).

```
Sample statistic (Global R): -0.048
Significance level of sample statistic: 86.9%
Number of permutations: 999 (Random sample from 24310)
Number of permuted statistics greater than or equal to Global R: 868
```

Appendix B6: Result of the one-way ANOSIM on the nematode species density between sites (Teluk Awar horizontal study).

```
Sample statistic (Global R): 0.169
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0
```

Appendix B7: Result of the one-way ANOSIM on the nematode species density among stations (Teluk Awar horizontal study).

```
Sample statistic (Global R): 0.761
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0
```

Appendix B8: Result of the one-way ANOSIM on the marine nematodes functional feeding group (FFG) between sites (Teluk Awar horizontal study).

```
Sample statistic (Global R): 0.047
Significance level of sample statistic: 15.6%
Number of permutations: 999 (Random sample from 24310)
Number of permuted statistics greater than or equal to Global R: 155
```

Appendix B9: Result of the one-way ANOSIM on the marine nematodes functional feeding group (FFG) among stations (Teluk Awar horizontal study).

```
Sample statistic (Global R): 0
Significance level of sample statistic: 44.2%
Number of permutations: 999 (Random sample from 190590400)
Number of permuted statistics greater than or equal to Global R: 441
```

Appendix B10: Result of the one-way ANOSIM on the environmental parameters between sites (Teluk Awar vertical study).

```
Sample statistic (Global R): 0.033
Significance level of sample statistic: 30.6%
Number of permutations: 999 (Random sample from 1716)
Number of permuted statistics greater than or equal to Global R: 305
```

Appendix B11: Result of the one-way ANOSIM on the environmental parameters among stations (Teluk Awar vertical study).

```
Sample statistic (Global R): 0.371
Significance level of sample statistic: 1.3%
Number of permutations: 999 (Random sample from 135135)
Number of permuted statistics greater than or equal to Global R: 12
```

Appendix B12: Result of the one-way ANOSIM on the marine nematode assemblages between sites (Teluk Awar vertical study).

```
Sample statistic (Global R): 0.031
Significance level of sample statistic: 0.5%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 4
```

Appendix B13: Result of the two-way ANOSIM on the marine nematode assemblages between stations and depth (Teluk Awar vertical study).

TESTS FOR DIFFERENCES BETWEEN Station GROUPS *(across all Depth groups)* Sample statistic (Global R): 0.121 Significance level of sample statistic: 0.1% Number of permutations: 999 (Random sample from a large number) Number of permuted statistics greater than or equal to Global R: 0	*TESTS FOR DIFFERENCES BETWEEN Depth GROUPS* *(across all Station groups)* *Global Test* Sample statistic (Global R): 0.45 Significance level of sample statistic: 0.1% Number of permutations: 999 (Random sample from a large number) Number of permuted statistics greater than or equal to Global R: 0

Appendix B14: Result f the one-way ANOSIM on the functional feeding group (FFG) across sediment depth (Teluk Awar vertical study).

```
Sample statistic (Global R): 0.35
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0
```

Appendix B15: Result of the one-way ANOSIM on the marine nematode assemblages between months for sandy site (Teluk Awar seasonal study).

```
Sample statistic (Global R): 0.735
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0
```

Appendix B16: Result of the one-way ANOSIM on the marine nematode assemblages between months for muddy site (Teluk Awar seasonal study).

```
Sample statistic (Global R): 0.489
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to Global R: 0
```

Appendix C1: Result of the BioEnv on the nematode assemblages and environmental parameters for Sarawak coastal waters.

Variables	Best results
1 pH	No.Vars Corr. Selections
2 DO	4 0.311 1,2,5,6
3 Temperature	
4 Salinity	
5 Sand	
6 Silt	
7 clay	

Appendix C2: Result of the BioEnv on the nematode assemblages and environmental parameters for site A (Teluk Awar horizontal study).

Variables	Best results
1 Sand	No.Vars Corr. Selections
2 Silt	3 0.647 7-9
3 Clay	
4 pH	
5 DO	
6 Chl *a*	
7 TOM	
8 Salinity	
9 Temperature	

Appendix C3: Result of the BioEnv on the nematode assemblages and environmental parameters for site B (Teluk Awar horizontal study).

Variables	Best results
1 Sand	No.Vars Corr. Selections
2 Silt	3 0.604 3,7,9
3 Clay	
4 pH	
5 DO	
6 Chl *a*	
7 TOM	
8 Salinity	
9 Temperature	

Appendix C4: Result of the BioEnv on the nematode assemblages and environmental parameters for seasonal study (sandy site).

Variables	*Best results*
1 Mean pH	No.Vars Corr. Selections
2 Mean DO	5 0.588 2-4,9,11
3 Mean temperature	
4 Mean salinity	
5 Mean TOM	
6 Mean Chl a	
7 Mean Rainfall	
8 Mean Surface Temperature	
9 Sand	
10 Silt	
11 Clay	

Appendix C5: Result of the BioEnv on the nematode assemblages and environmental parameters for seasonal study (muddy site).

Variables	*Best results*
1 Mean pH	No.Vars Corr. Selections
2 Mean DO	5 0.743 1,3,5,10,11
3 Log(Mean temperature)	6 0.730 1,3,5,8,10,11
4 Mean salinity	
5 Mean TOM	
6 Log(Mean Chl a)	
7 Mean Rainfall	
8 Mean Surface Temperature	
9 Sand	
10 Silt	
11 Clay	

Appendix D1: Percentage contribution of similarity and dissimilarity of species among site A and B (SIMPER).

Nematode species	A Similarity % contribution	Nematode species	B Similarity % contribution	Nematode species	A vs B Dissimilarity % contribution
Daptonema tenuispiculum	59.05	*Daptonema hirsutum*	38.23	*Daptonema tenuispiculum*	10.91
Daptonema hirsutum	17.06	*Pierrickia vitielloi*	5.37	*Daptonema hirsutum*	9.77
Trichotheristus mirabilis	7.83	*Sphaerolaimus macrocirculus*	5.13	*Trichotheristus mirabilis*	3.39
Viscosia stenolaima	2.29	*Hopperia massiliensis*	4.98	*Sphaerolaimus macrocirculus*	3.20
Daptonema setifer	2.20	*Thalassomonhystera* sp	3.23	*Viscosia stenolaima*	2.56
Hopperia muscatensis	1.22	*Spilophorella candida*	3.21	*Hopperia massiliensis*	2.47
Sabatieria heipi	1.22	*Viscosia antartica*	3.13	*Pierrickia vitielloi*	2.27
		Sphaerolaimus gracilis	3.12	*Sphaerolaimus gracilis*	1.89
		Parodontophora pacifica	2.92	*Parodontophora pacifica*	1.84
		Daptonema tenuispiculum	2.91	*Diodontolaimus tunuispiculum*	1.82
		Diodontolaimus tunuispiculum	2.12	*Spilophorella candida*	1.72
		Oxyonchus australis	2.10	*Hopperia muscatensis*	1.72
		Sabatiera heterura	2.03	*Sabatieria heipi*	1.72
		Daptonema conicum	2.01	*Thalassomonhystera sp*	1.66
		Viscosia langrunensis	1.58	*Daptonema setifer*	1.64
		Parodontophora xenoticha	1.52	*Belbolla assupplementata*	1.60
		Viscosia cobbi	1.47	*Viscosia antartica*	1.45
		Viscosia tumidula	1.32	*Sabatiera heterura*	1.32
		Pierrickia aequalis	1.23	*Eudiplogaster* sp 1	1.32
		Desmolorenzenia spec	1.16	*Daptonema grahami*	1.31
		Sphaerolaimus islandicus	0.93	*Daptonema conicum*	1.20
		Trichotheristus erectus	0.79	*Sabatieria hilarula*	1.15
				Daptonema normandicus	1.14
				Viscosia stenostoma	1.13
				Parodontophora xenoticha	1.10

Oxyonchus australis	1.10
Viscosia cobbi	1.01
Sabatieria furcillata	0.99
Daptonema riemanni	0.97
Sphaerolaimus pacificus	0.97
Polygastrophora septembulba	0.95
Viscosia epapillosa	0.94
Trichotheristus erectus	0.93
Daptonema fissendens	0.86
Sabatieria longicaudata	0.84
Viscosia langrunensis	0.83
Trichotheristus floridanus	0.80
Daptonema curvispiculum	0.78
Pierrickia aequalis	0.78
Sphaerolaimus islandicus	0.77
Viscosia tumidula	0.76
Viscosia separabilis	0.75
Sabatieria stekhoveni	0.74
Desmolorenzenia spec	0.72
Sphaerolaimus horrendus	0.70
Marylynnia sp	0.70
Sabatiera intermissa	0.65
Daptonema oxycerca	0.64
Pomponema polydonta	0.61
Viscosia erasmi	0.60
Sphaerolaimus lamasus	0.58
Parodontophora brevamphida	0.57
Daptonema uncinatus	0.55
Sabatieria paradoxa	0.54
Paracomesoma longispiculum	0.54

Sabatieria intermissa	0.51
Daptonema vicinus	0.51
Polygastrophora omercooperi	0.51
Promonhystera tricuspidata	0.51
Daptonema laxus	0.50
Dorylaimid sp 1	0.50
Oxystomina elongata	0.45
Daptonema trabeculosom	0.44
Viscosia leptolaima	0.40
Sabatieria punctata	0.38
Viscosia isotonchula	0.38
Sphaerolaimus balticus	0.38
Oxystomina asetosa	0.36

Appendix E1: Mean percentage on marine nematode species density for Sarawak coastal waters study.

Nematode species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Anoplostoma viviparum	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-
Bathyeurystomina sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13.0	-	-	-	-
Calytronema setifer	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetonema canellatum	9.0	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetonema longisetum	-	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetonema sp	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Choniolaimus papilatus	-	-	-	-	-	-	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-
Cobbia dentata	-	14.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cobbia scutata	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema anticulatum	-	-	-	-	11.0	-	-	-	-	6.0	-	-	-	-	-	-	-	-	3.0	-
Daptonema curvatus	-	-	-	-	-	-	-	-	-	6.0	-	-	-	10.0	-	-	-	-	-	-
Daptonema fimbriatus	-	-	-	-	-	1.0	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-
Daptonema fissendens	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema grahami	-	-	-	-	7.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema hirsutum	-	7.0	-	-	-	-	-	-	-	-	-	67.0	-	-	-	4.0	-	-	-	-
Daptonema invagiferoum	-	-	-	-	-	-	-	9.0	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema laxus	-	-	-	-	-	12.0	7.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema setifer	-	-	-	-	-	1.0	9.0	9.0	-	12.0	-	-	-	-	-	-	-	25.0	-	-
Daptonema tenuispiculum	35.0	-	5.0	-	-	-	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-
Daptonema trabeculosus	-	-	-	-	15.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema uncinatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.0	-	-	-
Daptonema vicinus	-	-	-	-	-	-	-	-	-	-	-	-	-	50.0	-	-	-	-	-	-
Dorylaimid sp 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13.0	-	-	-	4.0	-
Dorylaimid sp 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19.0	-	-	-	-	-
Gairleanema anaremilae	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gamphionema typicum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.0
Halalaimus culiocaudatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-

Halichoanolaimus consimilis	-	-	-	-	11.0	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-
Hopperia australis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-
Hopperia massiliensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-
Metachromadora namibiensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65.0	-	-	-	-	-
Metachromadora onyxoides	-	-	-	-	-	-	23.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metachromadora pneumatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.0	-
Metachromadora pulvinata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.0
Metachromadora sp	-	-	-	-	4.0	4.0	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metoncholaimus pristiurus	-	-	-	-	-	-	-	-	-	-	-	33.0	-	-	-	-	-	-	-	-	-
Neochromadora complexa	-	-	-	-	-	-	-	46.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Neochromadora lineata	-	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-	-
Nudora longisetum	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nudora nuda	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nudora omercooperi	-	-	-	-	-	18.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nudora sp	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nudora steineri	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nudora thorakista	-	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Onyx perfectus	-	-	-	-	-	-	-	7.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Onyx rugata	-	-	-	-	-	-	-	11.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Paracanthonchus sp	-	71.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parodontophora danka	-	-	-	-	7.0	-	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-	-
Parodontophora pacifica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.0	-	-	-	-
Perspiria papillata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	75.0	-	-	-
Pomponema ammophilum	-	7.0	-	-	-	17.0	1.0	9.0	-	-	-	-	-	-	-	-	-	-	1.0	-	-
Pomponema astrodes	-	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	11.0	-	-	-	25.0	-
Pomponema cyatholaimoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-	-	-	-	-
Pomponema debile	-	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-	-
Pomponema loticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-
Pomponema polydonta	-	-	-	-	11.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomponema syltense	-	-	-	-	11.0	-	-	-	-	-	-	-	-	-	-	4.0	-	-	-	-	-

Pomponema tautraensis	-	-	-	-	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudocella grannifera	17.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudocella tabarini	-	-	-	-	-	-	-	-	70.0	-	-	-	-	-	-	-	-	-	-	-	-
Pseudolella bangalensis	-	-	95.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatieria alata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.0	-
Sabatieria granifer	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-	-	-	-	-	-	-	-
Sabatieria intermissa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-	-
Sabatieria lawsi	-	-	-	-	-	-	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
Sabatieria ornata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.0	-	-	-	-	-	-
Sabatieria viscola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.0	-	-	-	-
Southernia zosterae	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus lodosus	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	4.0	-
Sphaerolaimus macrocirculus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-
Sphaerolaimus megamphis	-	-	-	-	-	-	-	-	-	-	-	-	13.0	-	-	-	-	-	-	-	-
Spilophorella papillata	-	-	-	-	-	-	-	-	14.0	-	-	-	-	-	-	-	-	-	-	-	-
Spirinia parasitifera	-	-	-	-	-	-	-	-	-	-	-	-	13.0	40.0	-	-	-	-	-	-	-
Sprinia sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-	-
Terschellingia brevicauda	-	-	-	-	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terschellingia longicaudata	39.0	-	-	-	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Theristus scanicus	-	-	-	-	11.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trileptium longisetum	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trileptium otti	-	-	-	-	-	25.0	38.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trileptium parisetum	-	-	-	-	-	-	11.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trileptium salvadoriense	-	-	-	-	-	-	-	9.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia antartica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.0	-
Viscosia erasmi	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia nuda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-
Viscosia separabilis	-	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-	-
Viscosia stenolaima	-	-	-	-	-	4.0	7.0	2.0	-	-	-	-	-	-	6.0	-	-	-	1.0	-	
Viscosia viscosa	-	-	-	-	-	-	-	-	-	53.0	-	-	-	-	-	-	-	-	-	-	-

Appendix E2: Functional feeding group and the percentage contribution of each nematode species in Teluk Awar (Site A and B).

Nematode species	FFG	Site	Station 1 %	Station 2 %	Station 3 %	Station 4 %	Station 5 %	Station 6 %	Station 7 %	Station 8 %	Station 9 %
Anoplostoma camus	1B	A	-	2.6	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Belbolla assupplementata	2A	A	-	-	-	2.2	3.6	8.3	-	-	-
		B	-	-	-	-	-	-	1.4	-	-
Calyptronema cobbi	2B	A	-	-	5.6	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema australis	1B	A	-	-	-	-	-	-	-	-	-
		B	0.7	-	-	-	-	-	-	-	-
Daptonema conicum	1B	A	-	-	-	-	-	-	-	-	-
		B	7.4	-	-	-	-	-	2.8	-	-
Daptonema curvispiculum	1B	A	27.2	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema fissendens	1B	A	18.2	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema frabeculosom	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	0.7	-	-
Daptonema grahami	1B	A	-	-	-	6.5	-	-	2.9	-	-

		B	-	-	-	-	-	-	-	-	-
Daptonema hirsutum	1B	A	6.1	-	19.4	10.9	14.3	-	23.5	-	-
		B	-	-	65.2	100	22	-	35.5	-	-
Daptonema laxus	1B	A	-	-	5.6	2.2	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema normandicus	1B	A	3.0	-	-	-	-	-	-	-	-
		B	-	-	-	-	15.9	-	-	-	-
Daptonema oxycerca	1B	A	3.0	2.6	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema procerum	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	2.1	-	-
Daptonema riemanni	1B	A	-	-	5.6	-	-	-	8.8	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema sentiens	1B	A	-	-	-	2.2	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema setifer	1B	A	-	-	11.1	2.2	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema setosum	1B	A	-	-	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema tenuispiculum	1B	A	6.1	7.7	16.7	50	35.7	62.5	23.5	33.3	-
		B	10.2	-	-	-	-	-	9.2	-	-
Daptonema trabeculosom	1B	A	-	-	-	-	-	-	-	-	-

		B	-	-	-	-	-	-	5	-	-
Daptonema uncinatus	1B	A	-	2.6	5.6	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Daptonema vicinus	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	4.5	-	-	-	-	-	-
Desmolorenzenia spec	1A	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	14.3
Diodontolaimus tunuispiculum	2A	A	-	-	-	-	-	-	-	-	-
		B	-	37.8	-	-	-	-	-	-	-
Ditlevsenella sp	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	1.4	-	-
Dorylaimida sp 1	FW	A	6.1	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Dracognomus dermatoglyphus	1A	A	-	-	-	-	-	-	2.9	-	-
		B	-	-	-	-	-	-	-	-	-
Drepanodorylaimus sp 1	FW	A		-	-	-	3.6	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Eudiplogaster sp 1	FW	A	6.2	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Eumorpholaimuss sabulicolus	1B	A	3.0	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Hopperia muscatensis	2A	A	-	-	-	-	-	-	-	16.7	33.3

		B	-	-	-	-	-	-	-	-	-
Hopperia australis	2A	A	-	-	-	-	-	-	-	-	-
		B	1.1	-	-	-	-	-	-	-	-
Hopperia massiliensis	2A	A	-	-	-	-	-	-	-	-	-
		B	-	43.2	-	-	5.3	-	-	-	-
Marylynnia sp	2A	A	-	-	-	-	-	-	-	-	-
		B	7.4	-	-	-	-	-	-	-	-
Neochomadora poecilosoma	2A	A	-	-	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Oxyonchus australis	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	28.6
Oxystomina asetosa	1A	A	-	-	-	2.2	-	-	-	-	-
		B	-	-	-	-	0.7	-	-	-	-
Oxystomina elongata	1A	A	-	2.6	-	-	-	-	-	-	-
		B	0.7	-	-	-	0.7	-	-	-	-
Oxystomina vespertilio	1A	A	-	-	-	-	-	-	-	-	-
		B	-	-	0.7	-	-	-	-	-	-
Paracomesoma longispiculum	2A	A	-	-	-	-	-	4.2	-	-	-
		B	-	-	-	-	-	-	-	-	-
Paradontophora brevamphida	2A	A	-	-	-	-	-	-	-	-	-
		B	4.9	-	-	-	-	-	-	-	-
Paradontophora pacifica	2A	A	-	2.6	-	2.2	-	-	-	-	-

		B	1.4	-	-	-	-	-	-	-	-
Paradontophora xenotricha	2A	A	-	-	-	-	-	-	-	-	-
		B	5.6	-	-	-	-	-	-	-	-
Paramesonchium belgicum	2A	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	0.7	-	-
Paramesonchium seriale	2A	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	0.8	-	-	-	-
Parodontophora cobbi	2A	A	-	2.6	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Parodontophora diegoensis	2A	A	-	2.6	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Parodontophora pacifica	2A	A	-	2.6	-	2.2	-	-	-	-	-
		B	-	16.2	-	-	-	-	-	-	-
Parodontophora quadristicha	2A	A	-	-	3.0	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Parodontophora xenoticha	2A	A	-	-	0.7	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Perspiria papilata	1B	A	-	-	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Pierrickia aequalis	1A	A	-	-	-	-	-	-	-	-	-
		B	0.7	-	-	-	6.1	-	-	-	-
Pierrickia vitiellοi	1A	A	-	-	-	-	-	-	-	-	-

		B	-	-	-	-	5.3	5-	-	-	-
Polygastrophora attenuata	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	0.7	-	-
Polygastrophora omercooperi	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	4.3	-	-
Polygastrophora septembulba	2B	A	-	-	-	-	-	-	-	16.7	-
		B	-	-	-	-	-	-	1.4	-	-
Pomponema polydonta	2B	A	9.1	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Pomponema tesselatum	2B	A	3.0	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Procamacolaimus acer	2A	A	3.0	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Promonhystera tricuspidata	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	2.3	-	-	-	-
Rhips gracilicauda	2A	A	-	-	-	-	-	-	2.9	-	-
		B	-	-	-	-	-	-	-	-	-
Sabatiera celtica	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	0.7	-	-
Sabatiera heterura	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	28.6	-	-	-
Sabatiera intermissa	1B	A	-	-	-	-	-	-	-	-	-

		B	-	-	-	-	5.3	-	0.7	-	-
Sabatiera pomarei	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	0.7	-	-
Sabatiera splendens	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	0.7	-	-
Sabatieria furcillata	1B	A	-	-	2.8	2.2	-	4.2	-	-	-
		B	-	-	-	-	-	-	-	-	-
Sabatieria heipi	1B	A	-	-	-	-	-	-	-	33.3	-
		B	-	-	-	-	-	-	-	-	-
Sabatieria hilarula	1B	A	-	-	-	-	-	4.2	17.6	-	-
		B	-	-	-	-	-	-	-	-	-
Sabatieria intermissa	1B	A	-	2.6	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Sabatieria longicaudata	1B	A	-	-	-	-	14.3	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Sabatieria paradoxa	1B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	7.1	-	-	-
Sabatieria punctata	1B	A	-	-	-	-	3.6	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Sabatieria stekhoveni	1B	A	-	-	-	-	3.6	-	-	-	-
		B	3.9	-	-	-	-	-	-	-	-
Setosabatieria hilarula	1B	A	-	-	-	-	-	-	-	-	-

		B	-	-	-	-	-	-	0.7	-	-
Sphaerolaimus horrendus	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	6.06	-	-	-	-	-	-
Sphaerolaimus caspius	2B	A	-	-	-	-	-	-	-	-	-
		B	0.7	-	-	-	-	-	-	-	-
Sphaerolaimus gracilis	2B	A	-	2.6	-	2.2	-	-	-	-	-
		B	4.6	-	12.1	-	-	-	-	-	-
Sphaerolaimus islandicus	2B	A	-	2.6	-	-	-	-	-	-	-
		B	0.4	2.7	-	-	-	-	-	-	-
Sphaerolaimus lamasus	2B	A	-	7.7	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Sphaerolaimus macrocirculus	2B	A	-	-	-	6.5	3.6	-	-	-	-
		B	30.3	-	0.7	-	-	-	12.8	-	-
Sphaerolaimus pacificus	2B	A	-	-	-	4.3	-	-	-	-	-
		B	7.4	-	-	-	-	-	-	-	-
Sphaerolaimus paragracillis	2B	A	-	-	-	2.2	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Sphaerolaimus uncinutus	2B	A	-	2.6	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Spilophorella candida	2A	A	-	-	-	-	-	-	-	-	-
		B	12.7	-	-	-	-	-	9.9	-	-
Spilophorella tasmaniensis	2A	A	-	-	-	-	-	-	2.9	-	-

		B	-	-	-	-	-	-	-	-	-
Stylotheristus mutila	1B	A	-	-	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Symplocastoma brevispiculum	FW	A	3.0	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Symplocastoma tenuicolle	FW	A	-	-	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Terschellingia communis	1A	A	-	-	-	2.2	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Thalassomonhystera sp	1A	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	42.9
Theristus heterospicules	1B	A	-	2.6	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Trichotheristus erectus	1A	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	15.9	-	-	-	-
Trichotheristus floridanus	1A	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	9.9	-	-
Trichotheristus galeatus	1A	A	-	-	-	-	-	4.2	-	-	-
		B	-	-	-	-	-	-	-	-	-
Trichotheristus mirabilis	1A	A	-	-	-	-	-	8.3	2.9	-	66.7
		B	-	-	-	-	-	-	-	-	-
Viscosia poseidonica	2B	A	-	-	-	-	-	-	2.9	-	-

		B	-	-	-	-	-	-	-	-	-
Viscosia abyssorum	2B	A	-	-	-	-	-	-	-	-	-
		B	0.7	-	-	-	0.7	-	-	-	-
Viscosia antartica	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	5.3	14.3	-	-	-
Viscosia cobbi	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	3.0	-	6.8	-	-	-	-
Viscosia epapillosa	2B	A	3.0	-	-	-	-	4.2	5.9	-	-
		B	-	-	-	-	-	-	-	-	-
Viscosia erasmi	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	6.1	-	-	-	-	-	-
Viscosia isotonchula	2B	A	-	-	-	-	7.1	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Viscosia langrunensis	2B	A	-	-	-	-	-	-	-	-	-
		B	1.8	-	-	-	4.5	-	-	-	-
Viscosia leptolaima	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	14.3
Viscosia minor	2B	A	-	-	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Viscosia parasetosa	2B	A	-	-	-	-	-	-	-	-	-
		B	0.4	-	-	-	-	-	-	-	-
Viscosia poseidonica	2B	A	-	-	-	-	-	-	2.9	-	-

		B	-	-	-	-	-	-	-	-	-
Viscosia separabilis	2B	A	-	-	2.8	-	3.6	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Viscosia stenolaima	2B	A	-	33.3	-	-	3.6	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Viscosia stenostoma	2B	A	-	20.5	-	-	3.6	-	-	-	-
		B	-	-	-	-	-	-	-	-	-
Viscosia tumidula	2B	A	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	4.5	-	1.4	-	-
Viscosia viscosa	2B	A	-	-	2.8	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-

Appendix E3: Functional feeding group and the percentage contribution of each nematode species in different depth in Teluk Awar (Site A).

Nematode Species	FFG	A1(0-5)	A1(6-10)	A1(11-15)	A2(0-5)	A2(6-10)	A2(11-15)	A3(0-5)	A3(6-10)	A3(11-15)	A4(0-5)	A4(6-10)	A4(11-15)	A5(0-5)	A5(6-10)	A5(11-15)	A6(0-5)	A6(6-10)	A6(11-15)	A7(0-5)	A7(6-10)	A7(11-15)
Anoplostoma camus	1B	-	-	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Belbolla assupplementata	2A	-	-	-	-	-	-	-	-	-	-	6.5	-	4.0	-	-	8.5	-	-	-	-	-
Calyptronema cobbi	2B	-	-	-	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema australis	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema conicum	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema curvispiculum	1B	34.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema fissendens	1B	23.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema frabeculosom	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema grahami	1B	-	-	-	-	-	-	-	-	-	9.2	-	-	-	-	-	-	-	-	3.0	-	-
Daptonema hirsutus	1B	7.9	-	-	-	-	-	20.6	-	-	11.4	8.8	-	16.1	-	-	-	-	-	24.2	-	-
Daptonema laxus	1B	-	-	-	-	-	-	6.0	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-
Daptonema normandicus	1B	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema oxycerca	1B	3.8	-	-	2.8	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema procerum	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema rienanni	1B	-	-	-	-	-	-	6.0	-	-	-	-	-	-	-	-	-	-	-	9.1	-	-
Daptonema sentiens	1B	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-
Daptonema setifer	1B	-	-	-	-	-	-	8.8	50.0	-	3.0	-	-	-	-	-	-	-	-	-	-	-
Daptonema setosum	1B	-	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema tenuispiculum	1B	7.9	-	-	8.6	-	-	17.7	-	-	40.0	65.7	-	40.4	-	-	62.6	-	-	24.2	-	-
Daptonema trabeculosom	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema uncinatus	1B	-	-	-	2.8	-	-	6.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema vicinus	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Desmolorenzenia spec	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diodontolaimus tunuispiculum	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ditlevsenella sp	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dorylaimid sp	FW	7.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Dracognomus dermatoglyphus	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	
Drepanodorylaimus sp	FW	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-	-	-	-	-	-	-	
Eudiplogaster sp	FW	-	-	40.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Eumorpholaimuss sabulicolus	1B	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Hopperia muscatensis	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Hopperia australis	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Hopperia massiliensis	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Marylynnia sp	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Neochomadora poecilosoma	2A	-	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	
Oxyonchus australis	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Oxystomina asetosa	1A	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	
Oxystomina elongata	1A	-	-	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Oxystomina vespertilio	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Paracomesoma longispiculum	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.1	-	-	-	-	
Paramesonchium belgicum	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Paramesonchium seriale	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Parodontophora brevamphida	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Parodontophora cobbi	2A	-	-	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Parodontophora diegoensis	2A	-	-	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Parodontophora pacifica	2A	-	-	-	2.8	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	
Parodontophora quadristicha	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Parodontophora xenoticha	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Perspiria papilata	1B	-	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pierrickia aequalis	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pierrickia vitiellot	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Polygastrophora attenuata	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Polygastrophora omercooperi	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Polygastrophora septembulba	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pomponema polydonta	2B	-	100	19.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pomponema tesselatum	2B	-	-	19.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Procamacolaimus acer	2A	-	-	19.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Promonhystera tricuspidata	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhips gracilicauda	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-
Sabatiera celtica	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatiera heterura	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatiera intermissa	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatiera pomarei	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatiera splendens	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatieria furcillata	1B	-	-	-	-	-	-	2.9	-	-	-	6.5	-	-	-	-	4.1	-	-	-	-	-	-
Sabatieria heipi	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatieria hilarula	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.1	-	-	18.3	-	-	-
Sabatieria intermissa	1B	-	-	-	2.8	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatieria longicaudata	1B	-	-	-	-	-	-	-	-	-	-	-	-	16.1	-	-	-	-	-	-	-	-	-
Sabatieria paradoxa	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatieria punctata	1B	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-	-	-	-	-	-	-	-	-
Sabatieria stekhoveni	1B	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-	-	-	-	-	-	-	-	-
Setosabatieria hilarula	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus horrendus	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus balticus	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus caspius	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus gracilis	2B	-	-	-	2.8	-	-	-	-	-	3.0	6.5	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus islandicus	2B	-	-	-	-	-	51.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus lamasus	2B	-	-	-	8.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus macrocirculus	2B	-	-	-	-	-	-	-	-	-	9.2	6.5	-	4.0	-	-	-	-	-	-	-	-	-
Sphaerolaimus pacificus	2B	-	-	-	-	-	-	-	-	-	6.2	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus paragracilis	2B	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus uncinutus	2B	-	-	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spilophorella candida	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spilophorella tasmaniensis	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-
Stylotheristus mutila	1B	-	-	-	-	-	-	-	50.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Symplocastoma brevispiculum	FW	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Symplocastoma tenuicolle	FW	-	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Terschellingia communis	1A	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	-	-	-	-
Thalassomonhystera sp	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Theristus heterospicules	1B	-	-	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichotheristus erectus	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichotheristus floridanus	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichotheristus galeatus	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.1	-	-	-	-	-	-
Trichotheristus mirabilis	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.2	-	-	3.0	-	-	-
Viscosia poseidonica	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	-
Viscosia abyssorum	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia antartica	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia bandensis	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia cobbi	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia epapillosa	2B	3.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.1	-	-	6.2	-	-	-
Viscosia erasmi	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia isotonchula	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.	-	-	-	-	-	-	-
Viscosia langrunensis	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia leptolaima	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia minor	2B	-	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia parasetosa	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia poseidonica	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.
Viscosia separabilis	2B	-	-	-	-	-	-	2.9	-	-	-	-	-	-	100.	-	-	-	-	-	-	-	-
Viscosia stenolaima	2B	-	-	-	28.7	100.	51.9	-	-	-	-	-	-	4.0	-	-	-	-	-	-	-	-	-
Viscosia stenostoma	2B	-	-	-	22.9	-	-	-	-	-	-	-	-	4.0	-	-	-	-	-	-	-	-	-
Viscosia tumidula	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viscosia viscosa	2B	-	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix E4: Functional feeding group and the percentage contribution of each nematode species in different depth in Teluk Awar (Site B).

Nematode Species	FFG	B1(0-5)	B1(6-10)	B1(11-15)	B2(0 -5)	B2(6-10)	B2(11-15)	B3(0 -5)	B3(6-10)	B3(11-15)	B4(0 -5)	B4(6-10)	B4(11-15)	B5(0 -5)	B5(6-10)	B5(11-15)	B6(0 -5)	B6(6-10)	B6(11-15)	B7(0 -5)	B7(6-10)	B7(11-15)
Anoplostoma camus	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Belbolla assupplementata	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.9	-	-
Calyptronema cobbi	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema australis	1B	0.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema conicum	1B	7.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	3.9	-	-
Daptonema curvispiculum	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema fissendens	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema frabeculosom	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.7	-	-
Daptonema grahami	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema hirsutus	1B	0.0	-	-	0.0	-	-	62.8	-	-	100	-	-	30.7	-	-	0.0	-	-	34.8	-	-
Daptonema laxus	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema normandicus	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	12.9	-	-	0.0	-	-	0.0	-	-
Daptonema oxycerca	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema procerum	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	1.4	-	-
Daptonema riemanni	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema sentiens	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema setifer	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema setosum	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema tenuispiculum	1B	10	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	9.1	-	-
Daptonema trabeculosom	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	3.6	-	-
Daptonema uncinatus	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Daptonema vicinus	1B	0.0	-	-	0.0	-	-	2.9	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Desmolorenzenia spec	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Diodontolaimus tumuispiculum	2A	0.0	-	-	36.8	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-

Dilevsenella sp	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	1.4	-	-
Dorylaimid sp	FW	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Dracognomus ermatoglyphus	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Drepanodorylaimus sp 1	FW	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Eudiplogaster sp 1	FW	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Eumorpholaimuss sabulicolus	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Hopperia muscatensis	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Hopperia australis	2A	1.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Hopperia massiliensis	2A	0.0	-	-	42.1	-	-	0.0	-	-	0.0	-	-	4.3	-	-	0.0	-	-	0.0	-	-
Marylynnia sp	2A	7.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Neochomadora poecilosoma	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Oxyonchus australis	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Oxystomina asetosa	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.6	-	-	0.0	-	-	0.0	-	-
Oxystomina elongata	1A	0.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.6	-	-	0.0	-	-	0.0	-	-
Oxystomina vespertilio	1A	0.0	-	-	0.0	-	-	1.5	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Paracomesoma longispiculum	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Paramesonchium belgicum	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.7	-	-
Paramesonchium seriale	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.6	-	-	0.0	-	-	0.0	-	-
Parodontophora brevamphida	2A	4.9	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Parodontophora cobbi	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Parodontophora diegoensis	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Parodontophora pacifica	2A	1.4	-	-	15.8	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Parodontophora quadristicha	2A	0.0	-	-	0.0	-	-	2.9	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Parodontophora xenoticha	2A	5.6	-	-	0.0	-	-	4.4	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Perspiria papilata	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Pierrickia aequalis	1A	0.7	-	-	0.0	-	-	0.0	-	-	0.0	-	-	4.9	-	-	0.0	-	-	0.0	-	-
Pierrickia vitiellot	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	4.3	-	-	50.0	-	-	0.0	-	-

Polygastrophora attenuata	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.7	-	-
Polygastrophora omercooperi	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	4.2	-	-
Polygastrophora septembulba	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	1.4	-	-
Pomponema polydonta	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Pomponema tesselatum	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Procamacolaimus acer	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Promonhystera tricuspidata	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	5.8	-	-	0.0	-	-	0.0	-	-
Rhips gracilicauda	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sabatiera celtica	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.7	-	-
Sabatiera heterura	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	28.6	-	-	0.0	-	-
Sabatiera intermissa	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	4.6	-	-	0.0	-	-	0.7	-	-
Sabatiera pomarei	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.7	-	-
Sabatiera splendens	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.7	-	-
Sabatieria furcillata	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sabatieria heipi	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sabatieria hilarula	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sabatieria intermissa	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sabatieria longicaudata	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sabatieria paradoxa	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	7.1	-	-	0.0	-	-
Sabatieria punctata	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sabatieria stekhoveni	1B	3.8	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Setosabatieria hilarula	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.8	-	-
Sphaerolaimus horrendus	2B	0.0	-	-	0.0	-	-	5.8	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sphaerolaimus balticus	2B	0.0	-	-	2.6	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sphaerolaimus caspius	2B	0.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sphaerolaimus gracilis	2B	4.5	-	-	0.0	-	-	11.7	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sphaerolaimus islandicus	2B	0.3	-	-	2.6	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-

Sphaerolaimus lamasus	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sphaerolaimus macrocirculus	2B	3.0	-	-	0.0	-	-	1.5	-	-	0.0	-	-	0.0	-	-	0.0	-	-	12.5	-	-
Sphaerolaimus pacificus	2B	7.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sphaerolaimus paragracilis	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Sphaerolaimus uncinatus	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Spilophorella candida	2A	1.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	9.8	-	-
Spilophorella tasmaniensis	2A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Stylotheristus mutila	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Symplocastoma brevispiculum	FW	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Symplocastoma tenuicolle	FW	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Terschellingia communis	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Thalassomonhystera sp	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Theristus heterospicules	1B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Trichotheristus erectus	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	12.9	-	-	0.0	-	-	0.0	-	-
Trichotheristus floridanus	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	9.8	-	-
Trichotheristus galeatus	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Trichotheristus mirabilis	1A	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia poseidonica	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia abyssorum	2B	0.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.6	-	-	0.0	-	-	0.0	-	-
Viscosia antartica	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	4.3	-	-	14.3	-	-	0.0	-	-
Viscosia bandensis	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia cobbi	2B	0.0	-	-	0.0	-	-	2.9	-	-	0.0	-	-	5.5	-	-	0.0	-	-	0.0	-	-
Viscosia epapillosa	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia erasmi	2B	0.0	-	-	0.0	-	-	3.9	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia isotonchula	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia langrunensis	2B	1.7	-	-	0.0	-	-	0.0	-	-	0.0	-	-	3.7	-	-	0.0	-	-	0.0	-	-
Viscosia leptolaima	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-

Viscosia tumor	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia parasetosa	2B	0.3	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia poseidonica	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia separabilis	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia stenolaima	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia stenostoma	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-
Viscosia tumidula	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	3.7	-	-	0.0	-	-	1.4	-	-
Viscosia viscosa	2B	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-	0.0	-	-

Appendix E5: Functional feeding group and the percentage contribution of each nematode species for the sandy site in Teluk Awar (Seasonal study).

Nematode species	FFG	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09
Aegialoalaimus tenuis	1A	-	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Anoplostoma camus	1B	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyartonema germanicum	1A	-	-	-	-	-	-	-	-	-	-	2.2	-	-	-	-	-
Daptonema astrodes	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.1
Daptonema dubius	1B	-	-	-	-	3.4	-	-	-	-	-	-	-	-	-	-	-
Daptonema fissendens	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-
Daptonema hirsutum	1B	-	-	-	-	13.8	48.3	68.8	51.4	61.3	79.4	26.7	14.0	-	1.4	-	-
Daptonema lata	1B	-	-	-	-	-	-	4.2	-	-	-	-	-	-	-	-	-
Daptonema oxycerca	1B	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daptonema proprius	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0
Daptonema spirus	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-
Daptonema tenuispiculum	1B	5.7	-	3.3	1.1	-	-	2.1	2.9	29.0	0.9	-	2.3	0.6	-	3.2	-
Daptonema uncinatus	1B	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dorylaimid sp	FW	-	-	-	12.6	-	-	-	-	-	-	-	7.0	-	-	3.2	22.4
Eudiplogaster sp	FW	-	-	-	2.1	-	-	-	-	-	-	-	-	-	1.4	-	-
Halichoanolaimus conicaudatus	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoanolaimus ovalis	2B	-	33.7	31.1	-	-	6.9	-	-	-	0.9	-	-	54.7	36.4	30.2	2.0
Halichoanolaimus quattuordecimpapillatus	2B	-	-	-	3.2	-	1.7	-	-	-	-	-	-	-	-	-	-
Halichoanolaimus robustus	2B	-	0.8	1.6	-	-	1.7	-	-	-	-	-	-	0.6	-	1.6	-
Haliplectus floridanus	1A	-	-	-	4.2	-	-	-	-	-	-	-	4.7	-	-	-	-
Metadesmolaimus uncinatus	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0
Oxystomina elongata	1A	2.1	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxystomina vespertilio	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0

Parodontophora breviseta	2A	-	0.4	-	2.1	-	-	-	-	-	0.9	-	2.3	1.9	2.8	6.3	2.0
Parodontophora cobbi	2A	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parodontophora danka	2A	-	-	-	-	-	-	-	2.9	-	-	-	-	-	-	-	-
Parodontophora diegoensis	2A	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parodontophora marisjaponici	2A	-	-	3.3	3.2	-	-	-	-	-	-	-	-	-	-	-	-
Parodontophora pacifica	2A	1.9	6.7	11.5	2.1	10.3	-	-	17.1	-	-	6.7	4.7	2.5	4.2	-	18.4
Parodontophora polita	2A	-	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Parodontophora quadristicha	2A	-	-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-
Perspiria megamphida	1B	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-
Pomponema ammophilum	2B	-	-	-	5.3	-	-	-	-	-	-	-	-	-	-	-	-
Pomponema astrodes	2B	-	-	-	1.1	-	-	-	-	-	-	2.2	-	-	-	-	4.1
Pomponema calytrophorus	2B	-	-	-	-	-	-	-	-	-	-	-	2.3	-	-	-	-
Pomponema coomansi	2B	-	-	-	-	3.4	-	-	-	-	-	-	7.0	-	-	-	-
Pomponema cotylophorus	2B	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomponema loticum	2B	-	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomponema reducta	2B	-	-	-	3.2	-	-	-	-	-	-	-	-	-	-	-	-
Pomponema syltense	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.0
Pomponema tautraensis	2B	-	-	-	10.5	3.4	-	-	-	-	-	-	2.3	-	-	1.6	-
Ptycholaimellus sp	2A	-	-	-	-	-	-	-	-	-	0.9	-	-	-	-	-	-
Ptycholaimellus vincxae	2A	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-
Sabatieria abyssaris	1B	-	-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-
Sabatieria alata	1B	-	-	-	-	3.4	-	-	-	-	-	-	-	-	-	-	-
Sabatieria effilata	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.9	-
Sabatieria intermissa	1B	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	6.1
Sabatieria lawsi	1B	-	-	-	-	-	-	-	20.0	-	2.8	4.4	4.7	1.2	6.3	-	-
Sabatieria mortenseni	1B	-	-	-	-	6.9	-	-	-	-	-	-	-	-	-	-	-
Sabatieria ornata	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-

Sabatieria praedatrix	1B	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabatieria pulchra	1B	-	-	3.3	-	-	3.4	-	-	-	0.9	-	-	-	-	-	-	-
Sabatieria punctata	1B	-	-	-	-	6.9	1.7	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus gracilis	2B	1.9	0.4	1.6	5.3	-	1.7	-	-	3.2	1.9	11.1	2.3	-	-	-	2.0	
Sphaerolaimus islandicus	2B	1.9	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sphaerolaimus lamasus	2B	5.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sphaerolaimus lodosus	2B	-	9.4	3.3	-	-	1.7	-	-	-	-	2.2	-	3.7	10.5	1.6	2.0	
Sphaerolaimus macrocirculus	2B	-	2.0	1.6	6.3	24.1	1.7	-	-	6.5	-	11.1	7.0	1.9	3.5	9.5	8.2	
Sphaerolaimus uncinutus	2B	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Sphilophorella paradoxa	2A	-	-	3.3	-	-	-	-	-	-	-	-	-	1.9	0.7	-	-	
Spilophorella papillata	2A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3	-	
Spirinia megamphida	2A	-	-	-	-	-	-	-	-	-	0.9	-	-	-	-	-	-	
Spirinia parasitifera	2A	-	-	-	18.9	-	-	-	-	-	-	-	-	-	-	-	-	
Steineridora loricata	2A	-	-	-	-	-	-	-	-	-	-	2.2	-	-	-	-	-	
Terschellingia longicaudata	1A	-	-	-	3.2	-	-	2.1	-	-	0.9	-	4.7	-	0.7	-	-	
Theristus heterospicules	1B	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Viscosia antartica	2B	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Viscosia conicaudatus	2B	-	0.4	-	-	-	-	-	-	-	0.9	-	-	-	-	-	-	
Viscosia coomansi	2B	-	4.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Viscosia dubiosa	2B	-	-	-	-	-	-	4.2	-	-	-	-	-	-	-	-	-	
Viscosia erasmi	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	4.8	12.2	
Viscosia keiensis	2B	-	-	-	10.5	-	-	-	-	-	-	-	2.3	-	-	-	-	
Viscosia megalaima	2B	-	2.4	-	-	-	-	-	-	-	-	-	-	0.6	-	-	-	
Viscosia stenolaima	2B	24.8	13.3	8.2	-	13.8	5.2	12.5	2.9	-	1.9	22.2	30.2	20.5	17.5	14.3	4.1	
Viscosia stenostoma	2B	15.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Viscosia tumidula	2B	-	9.4	3.3	-	3.4	6.9	-	2.9	-	-	-	-	4.3	8.4	4.8	-	
Viscosia viscosa	2B	-	12.5	18.0	-	6.9	15.5	6.3	-	-	6.5	8.9	-	5.6	3.5	3.2	2.0	

Wieseria longicaudata	1A	-	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Wieseria stenolaima	1A	24.8	-	-	-	-	-	-	-	-	-	-	2.3	-	-	-	-	-

Appendix E6: Functional feeding group and the percentage contribution of each nematode species for the muddy site in Teluk Awar (Seasonal study).

Nematode species	FFG	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09
Anoplostoma viviparum	1A	-	-	-	-	-	-	-	4.2	-	-	-	-	-	-	-	-
Athernema unicum	FW	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calyptronema cobbi	2B	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calyptronema mawsoni	2B	-	-	-	-	-	-	1.8	-	-	-	-	-	-	-	-	-
Calyptronema maxweberi	2B	-	2.9	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-
Choniolaimus effilatus	2B	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-
Daptonema alternus	1B	-	-	-	-	-	-	-	-	-	1.2	-	-	-	-	-	-
Daptonema dentatus	1B	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-	-
Daptonema exutus	1B	-	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-
Daptonema grahami	1B	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-	-
Daptonema lata	1B	-	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-
Daptonema normandicum	1B	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-	-
Daptonema simplex	1B	-	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-
Daptonema tenuispiculum	1B	-	-	3.6	-	2.0	-	-	4.2	2.4	-	1.2	3.6	5.8	15.9	14.3	9.5
Daptonema uncinatus	1B	-	-	-	-	-	-	-	-	2.4	-	-	-	-	-	-	-
Demonema rapax	2B	-	-	-	-	1.0	6.3	-	-	-	-	-	-	-	-	-	-
Desmolaimus longicaudatus	1B	-	-	-	-	-	-	1.8	-	-	-	-	-	-	-	-	-
Desmolaimus mirabilis	1B	-	-	-	-	-	-	1.8	-	-	-	-	-	-	-	-	-
Diodontolaimus tenuispiculum	2A	26.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dorylaimid sp 1	FW	-	5.9	-	-	10.2	9.4	44.6	-	12.2	6.0	45.8	7.1	9.6	11.4	18.6	6.3
Dorylaimid sp 2	FW	-	5.9	-	-	-	3.1	14.3	-	-	-	1.2	-	-	-	-	-
Dorylaimid sp 3	FW	-	-	-	-	-	-	-	-	-	-	-	-	1.9	-	-	-
Halalaimus algeriensis	1A	-	-	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Halalaimus curoliniensis	1A	-	-	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Halichoanolaimus dolichurus	2B	-	-	-	-	-	-	-	-	-	-	15.7	-	7.7	-	-	2.1
Halichoanolaimus longicauda	2B	-	-	-	-	-	-	5.4	-	-	-	-	-	-	-	-	-

Halichoanolaimus microspiculum	2B	-	-	-	-	-	-	3.6	-	-	-	-	-	-	-	-	-	
Halichoanolaimus norvegicus	2B	-	-	-	-	-	-	-	-	-	-	-	1.8	-	-	-	-	
Halichoanolaimus robustus	2B	-	-	-	-	-	-	1.8	-	-	1.2	2.4	-	-	-	-	-	
Halichoanolaimus unicus	2B	-	-	-	-	-	-	-	-	7.3	-	-	-	-	-	-	-	
Haliplectus floridanus	1A	-	23.5	-	-	5.1	-	1.8	-	29.3	34.9	10.8	19.6	28.8	-	4.3	9.5	
Haliplectus schulzi	1A	-	2.9	14.3	-	7.1	12.5	3.6	12.5	-	-	-	-	-	-	-	-	
Haliplectus solicornius	1A	-	23.5	3.6	-	5.1	-	-	4.2	-	1.2	-	-	-	-	-	-	
Haliplectus soniocornius	1A	-	-	-	-	-	-	-	4.2	-	-	-	-	-	-	-	-	
Haliplectus tripapilatus	1A	-	5.9	14.3	-	-	3.1	-	-	-	-	-	-	-	-	-	-	
Hopperia massiliensis	2A	30.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Laimella annae	2A	-	-	-	-	-	-	-	4.2	-	-	-	-	-	-	-	-	
Litinium sp	1A	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Marylynia johanseni	2A	-	-	-	-	-	9.4	-	-	-	-	-	-	-	-	-	-	
Megadesmolaimus sp	1B	-	-	-	-	-	6.3	-	-	-	-	-	-	-	-	-	-	
Metachromadora suecica	2B	-	-	-	-	2.0	3.1	-	-	-	-	-	-	-	-	-	-	
Metadasynemoides sp	1A	-	-	-	-	-	3.1	-	-	-	-	-	-	-	-	-	-	
Metadesmolaimus aduncus	1B	-	-	-	16.7	-	-	-	-	-	-	-	-	-	-	-	-	
Oxystomina pulchella	1A	-	-	-	-	-	-	-	-	-	-	-	-	1.9	2.3	-	-	
Paracanthonchus kreisi	2A	-	-	-	-	-	3.1	-	-	-	-	-	-	-	-	-	-	
Parodontophora brevamphida	2A	-	-	-	-	-	-	-	4.2	-	-	-	-	3.8	-	-	-	
Parodontophora breviseta	2A	-	-	-	-	-	-	1.8	-	12.2	1.2	-	1.8	-	6.8	2.9	-	
Parodontophora chiliensis	2A	-	5.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Parodontophora pacifica	2A	11.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pomponema ammophilum	2B	-	-	-	-	-	6.3	1.8	-	-	-	-	1.8	-	-	-	-	
Pomponema astrodes	2B	-	-	-	-	-	-	-	-	-	1.2	-	-	-	-	-	-	
Pomponema breviseta	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3	-	1.1	
Pomponema carlyensis	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3	-	-	
Pomponema coomansi	2B	-	2.9	7.1	-	6.1	3.1	1.8	4.2	-	10.8	-	3.6	1.9	-	4.3	-	
Pomponema cotylophorum	2B	-	-	-	50.0	-	-	-	-	-	-	-	-	-	-	-	-	
Pomponema cyatholaimoides	2B	-	-	-	-	-	-	-	-	-	-	-	-	1.9	-	-	-	

Pomponema elegan	2B	-	-	-	-	-	-	-	4.2	-	1.2	-	-	-	-	-	-
Pomponema loticum	2B	-	-	-	-	4.1	-	1.8	4.2	2.4	1.2	-	-	-	-	-	-
Pomponema multipapillatum	2B	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-
Pomponema polydonta	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	-
Pomponema tautraensis	2B	-	-	-	-	8.2	-	-	-	-	-	-	-	1.9	-	-	-
Procheatosoma martensi	2A	-	-	-	-	-	-	-	8.3	-	-	-	-	-	-	-	-
Sabatieria heterura	1B	-	-	-	-	-	-	-	-	-	1.2	-	-	-	-	-	-
Sabatieria longicaudata	1B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.9	2.1
Sabatieria pulchra	1B	-	-	-	-	-	3.1	-	-	-	1.2	-	1.8	-	-	-	-
Sabatieria tenuiseta	1B	-	-	-	-	-	-	-	-	-	1.2	-	-	-	-	-	-
Sphaerolaimus asetosus	2B	-	-	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus balticus	2B	15.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus caspius	2B	-	2.9	10.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus gracilis	2B	-	-	-	-	-	-	-	-	4.9	1.2	1.2	5.4	-	-	1.4	-
Sphaerolaimus islandicus	2B	15.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus lodosus	2B	-	-	-	-	-	-	-	-	-	-	-	1.8	-	2.3	-	-
Sphaerolaimus macrocirculus	2B	-	-	7.1	-	4.1	-	-	8.3	4.9	10.8	6.0	10.7	11.5	15.9	18.6	12.6
Sphaerolaimus megaamphis	2B	-	-	-	-	-	3.1	-	-	4.9	-	-	-	-	-	-	-
Sphaerolaimus pacificus	2B	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus papilatus	2B	-	-	-	-	-	-	-	-	-	1.2	-	-	-	-	-	-
Sphaerolaimus paragracilis	2B	-	-	-	16.7	-	3.1	-	-	-	-	-	-	-	-	-	-
Sphaerolaimus pentasotus	2B	-	-	-	-	-	-	-	-	-	-	-	-	-	2.3	-	-
Sphaerolaimus uncinatus	2B	-	-	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Spilophorella paradoxoides	2A	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-
Terschellingia baylisi	1A	-	-	-	-	-	-	-	-	-	-	-	1.8	-	-	1.4	-
Terschellingia brevicauda	1A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1
Terschellingia communis	1A	-	-	-	-	-	-	-	-	-	-	-	3.6	-	-	-	-
Terschellingia gerlachi	1A	-	2.9	-	-	7.1	3.1	-	-	-	-	-	-	-	-	-	-
Terschellingia longicaudata	1A	-	2.9	21.4	-	27.6	18.8	7.1	29.2	4.9	10.8	13.3	26.8	19.2	34.1	28.6	54.7
Terschellingia longispiculata	1A	-	-	-	-	1.0	-	-	-	-	1.2	-	-	-	-	-	-

Viscosia carnleyensis	2B	-	-	-	-	2.0	-	3.6	-	4.9	-	1.2	-	3.8	-	-	-
Viscosia glabra	2B	-	-	-	-	1.0	-	1.8	-	-	-	-	1.8	-	-	-	-
Viscosia ketensis	2B	-	-	-	-	-	-	-	-	-	1.2	-	-	-	-	-	-
Viscosia microseta	2B	-	-	-	-	-	-	-	-	-	1.2	-	-	-	-	-	-
Viscosia stenolaima	2B	-	-	-	16.7	-	-	-	-	-	-	-	5.4	-	-	-	-
Viscosia viscosa	2B	-	-	-	-	-	-	-	4.2	-	1.2	1.2	1.8	-	4.5	1.4	1.1