1.0. INTRODUCTION

Marine polychaetes have attracted the attention of research workers for more than two reasons. First, the tubicolous polychaetes exhibit a marked diversity in morphological appearance and in the chemical composition of the tube. The texture of tube-houses of the members of the families Eunicidae, Chaetopteridae, Terebellidae (Branch Phanerocephala), Serpulidae, Sabellidae, Hermellidae (Branch Cryptocephala) may be membranous or calcareous and horny in nature (Defretin, 1971). The membranous tube is secreted by the ventral shield epithelium and is hardened by a specific chemical system to form more or less a cylindrical tube which internally lined by a hardened mucus having the appearance of silk (Benham, 1896; Muzi, 1968). On the other hand, calcifying organisms, such as serpulids, construct tubicolous houses with an admixture of calcium carbonate and mucopolysaccharide matrix material (Neff, 1969). It is likely that a study on the nature of the chemical composition of tubes of polychaetes may provide an insight into the range of adaptive radiation of polychaetes. Secondly, polychaetes are known to be one of the most common members of fouling communities. Fouling organisms include all marine forms which are attached to the fully or partially submerged surfaces of structures. (Purushotham and Satyanarayana Rao
1971). In the formation of "fouling complex" sabellids and serpulids play a significant role by their ability to construct a protective envelop around themselves which foul the surfaces of submerged marine installations. Other polychaetes of the families Nereidae, Syllidae, Amphinomidae, Cirratulidae, Eunicidae, Spionidae, Phyllodocidae, Serpulidae and Sabellidae are also a contributory factor in increasing the fouling intensity. Purushotham and Satyanarayana Rao (1971) have stressed the revenue loss due to fouling.

A cursory review on the morphology, minerology and chemical composition of tube and the environmental factors that affect tube formation, may highlight the importance the study has gained among research workers and focus the need for detailed study on the biology of polychaetes.

1.1. FAMILY EUNICIDAE:

Members of the species, Hyalinoeca latubicola (Family Eunicidae) secrete a horny tube of several concentric layers consisting of a combination of onuphic acid—a sugar phosphate polymer (Vinogradov, 1953; Pautard and Zola, 1968; Moerman, 1974)—and mucoprotein (Defretin, 1949, 1950, 1955). From a histochemical examination of the tube, Moerman (1974) besides reporting the occurrence of neutral polysaccharides, suggested that the protein moiety of the tube may undergo tanning. The tube of Eunice sp. was characterized by a
high content of calcium and sulphur (De Jorge et al., 1966) and magnesium (Vinogradov, 1953; De Jorge et al., 1966; Zola, 1967).

1.2. FAMILY CHAETOPTERIDAE:

Members of the species, Chaetopterus variopedatus, live in a 'U' shaped cylindrical, parchment like tube-house embedded within muddy substratum (Barnes, 1965). The mechanical rigidity of the tube has been attributed to the alignment of collagen fibres in an unstructural matrix (Brown and Ruse, 1971). Mineralogical studies of the tube indicate the presence of manganese in appreciable amounts. It has been shown that there may be interspecies variation in the content of manganese between Chaetopterus and Mesochaetopterus (Berkeley, 1922). The presence of manganese in the tube has been considered as a waste material excreted along with the tube building material. The work of De Jorge and Petersen (1968) provided a comparative account on the chemical constituents found in the mucus and tube of Chaetopterus variopedatus. The adaptive features of Chaetopterus, from the viewpoint of tube cleaning behaviour responses, were described by Brown and Rosen (1978).

1.3. FAMILY SPIONIDAE:

In a related species, Polydora, the antifouling property of the tube has been linked with the presence of protease activity (Zottoli and Carriker, 1974).
4. **FAMILY TEREBELLIDAE:**

Terebellids inhabit tubes cemented with sand grains, stones and broken shell (Watson, 1890). Brown and Ellis (1971), while studying the tube building habits of *Neoamphitrite robusta*, observed that the building activity and feeding behaviour are independent of each other.

In their study of the dwelling tube of *Amphitrite ornata*, Aller and Yingst (1978) emphasized the importance of the chemical composition of the tube in influencing the sediment chemistry of the habitat of polychaete and consequently the distribution of infauna.

1.5. **FAMILY SERPULIDAE:**

Serpulids have attracted the attention of many workers because of their high degree of adaptation to a sedentary mode of life. Serpulids are marine polychaetes which live in a calcareous tubes containing calcium carbonate and an organic matrix (Neff, 1971). The work of Thampi (1946) and Hedley (1956) provided detailed description of the morphology of tube and the tube building glands. Muzi (1968), from a histochemical study, reported that, sulphated mucigens comorise high percentage among the tube constituents of *Eupomatus dianthus*. The amino acid composition of calcified tubes of *Hydroides norvegicus* and *Eupomatus* was worked out by Mitterner (1971) who reported a high aspart
acid content in calcified tube and a low content in non-calcified tube.

It has been held by earlier workers that calcium necessary for tube building may be acquired in three ways: (1) It may be secreted by unicellular epidermal glands. (2) It may be secreted by the single pair of nephridia, the so-called tubiparous glands. And (3) some material may be secreted by the epidermis and cause precipitation of the calcareous material from sea water (see Swan, 1950). In this context it is of interest to mention that the ultrastructure of calcium phosphate containing cells of the peristomial glands of the serpulid *Pomatoceros caeruleus* was studied by Neff (1971) who postulated that cells in the epithelium of the anterior surface of the collar may act as storage sites for calcium and phosphorus. The work of Swan (1950) supported the report of Neff (1971). The anterior epithelium of the gut, the nephridia, and the chloragosomes of *P. triqueta* were found to contain calcium deposits. Nott and Parkes (1975) suggested that the larvae of *Spirobis spirorbis* do not store calcium for tube formation. They proposed that the worm's head with the branchial processes, operculum and collar were directly concerned with the extraction of calcium from sea water for incorporation in the secretion forming the tube. Supporting evidence for the absence of calcium reserve in the body was provided by the work of
Faouzi (1931) who reported the cessation of tube formation once the body calcium was exhausted. It would appear that polychaetes may use the body calcium initially and depend upon an external source such as the sea water for continued supply of calcium.

Studies on the minerology of the serpulids reveal that the tube is characterized by a combination of magnesium, calcium and aragonite (Bornhold and Milliman, 1973). They also reported that minerology of a serpulid may be controlled by genetic factors and modified by environmental conditions. Robertson and Pantin (1938) reported that the polychaete Pomatoceros triquetus, when reared in calcium free sea water, was unable to secrete the tube. The studies of Neff (1969) indicated that reduction in salinity below 20% had an adverse effect on tube formation. Further, differences in the nature and content of calcium between the temperate and tropical species of Hydrodus indicate the influential role of temperature on the minerology of polychaete tubes. It has been reported that environmental factors such as light, oxygen, depth, currents and food supply have a marked influence on the growth of tubes of Mercierella enigmatica (Shröder, 1967).
.6. **FAMILY SABELLARIDAE:**

Vovelle (1965) made histochemical remarks on the tube of *Sabellaria alveolata* and studied in detail the ultrastructure of the cement secretion glands. Quinone tanning had been suggested to confer mechanical rigidity on the worm-tube. He also observed that worms in the event of losing their house were unable to build a new one when there was no trace of any remnant of the old tube.

.7. **FAMILY SABELLIDAE:**

Sabellids generally secrete a membranous parchment like dwelling tubes (Dalyall, 1853, Meyer, 1887, Mcintosh, 1922). Nicol (1930) and Thampi (1946) gave a detailed account of the process of tube building in *Sabella pavonina* and *Dasychone cingulata* respectively. Wilson (1936), during the course of his studies on the development of few polychaetes, described in detail the tube building habits of *Branchiomma vesiculosum*. Fox (1938) reported that if *Sabella pavonina* was removed from its tube, the worm was unable to reconstruct a new one, and Fitzimons (1965) found that when *Sabellastarte magnifica* was deprived of its tube it would reconstruct an entirely new tube with the same appearance and structure. Thampi (1946), while working on *D. cingulata*, reported that rebuilding of the tube may be facilitated by the presence of particulate matter in sea water. It would appear that the behavioural response of sabellids may show wide variations in their ability to reconstruct a new tube.
From a histochemical examination of the tube of *Sabellastarte magnifica*, Fitzimones (1965) reported the incorporation of the sulphated acid mucopolysaccharide-protein complex as the principal chemical constituent of the membranous semitransparent tube. Cowden and Fitzharris (1975) demonstrated the presence of mucopolysaccharide-protein complex in the tentacle cartilage tissue of *Sabella melanostigma*. The work of Cameron (1914 and 1915) and Vinogradov (1953) provided basic information on the chemical composition of the tube as well as the body of *Sabella* and *Spirographis*. Recently, Defretin (1971) worked out the amino acid composition of the tubes of *Spirographis*, *Sabella* and *Myxicola*. That the tube of *Spirographis spallanzani* may have a second function of providing mechanical stimuli for the reflex body movements necessary for respiration was proposed by Fox (1938) who had studied the rate of oxygen uptake in animals with and without their protective tubes.

The ambit of the above review substantiates the statement of Defretin (1971) that "our knowledge of the tubes secreted by the polychaete worms is still very limited and the complete biochemical analysis of the tubes is necessary in each individual case in order to obtain significant results" (p.745). He also pointed out: "Chromotographic analysis, by revealing the amino acid composition of protein, could provide the information that cannot be derived with certainty from
Vovelle's histochemical studies from this point of view it was thought worthwhile to carry out a detailed biochemical and histochemical investigation of the tube of *D. cingulata*, a common fouler of Madras coast, together with a study on the environmental factors that influence the tube formation.

1.8. REVIEW OF WORK ON *D. CINGULATA* OF MADRAS COAST:

References in literature on the biology of *D. cingulata*, though fragmentary, provide information on some aspects of its biology. Aiyar and Subramaniam (1936) noted the occurrence of hermaphroditism in *D. cingulata*, while Thampi (1946) investigated the tube formation of *D. cingulata*. The work of Paul (1942) provided additional information on the growth and breeding of *D. cingulata*. Krishnan (1950) studied the structure of the nephridia and coelomducts of *D. cingulata*. The anatomical details of *D. cingulata* was reported by Thomas (1955). The behavioural response of *D. cingulata* with reference to light was studied by Srinivasasagam (1961).

From the foregoing resume it is evident that information on the chemical composition, histochemical and biochemical, mineralogy of the tube, the worm's adaptation to rebuild the tube under varied environmental conditions, similarities and dissimilarities, if any, in the chemical composition between the original tube and the freshly secreted tube, is not available. Further, *D. cingulata*
been reported to occur in Bombay, Visakhapatnam, Madras and not in Cochin, which may suggest the influence of salinity on distribution. It has been reported that the salinity of Cochin backwaters ranges from 0.28 to 33.84% (Cheriyan, 1973). In this context it is of interest to point out that during November and December the salinity of Madras waters may be diluted to about 19% (Muthu, 1956). A study on the relationship between salinity and the tube formation may be of interest from the viewpoint of biofouling engineering control. Since environmental factors act independently and collectively on organisms (Vernberg and Vernberg, 1972), an attempt has been made to study tube formation with reference to combination of environmental parameters.

Certain salts of heavy metals when brought into sea may interfere with the ecophysiology of the marine organisms. Mercury and copper compounds are among them which find their way to the marine biome through industrial wastes. The toxic and deleterious effects caused by these compounds on marine organisms are well known (Vernberg and Vernberg, 1972). From the studies of Bryan (1971) and Reish (1978) the detrimental effect of heavy metals on the metabolism of marine animals is known.
An aspect of local interest is the distribution of *D. cingulata* within harbour waters. It has been found that *D. cingulata* mainly inhabits the Boat Basin area of the harbour where routine repair and maintenance work of boats and ships are being done. Among the various regions of the harbour, viz., North quay, West quay, South quay, East quay Timber pond and Boat Basin, the last mentioned area receives the drainage (sewage) of the immediate surroundings as well as the discharge of waste oil from the motor boats. On enquiry it is found that 'red lead', which contains mercury as a paint ingredient, is being used to prevent the settlement of foulers (Personal discussion). Since tube building is a metabolic activity, in the present study, an attempt has been made to find out the effects of mercury and copper on tube formation and on subsequent accumulation, if any, of the metals in the newly formed tube.

In studies of assessing the biological fitness of an organism to its environment, emphasis is laid on its reproductive success. Therefore, to augment information on the biology of *D. cingulata* it was felt necessary to obtain information on the reproductive cycle, population ecology and larval recruitment of *D. cingulata*. 