Aquatic oligochaetes are small microscopic invertebrates (microdriles) mostly belong to families Naididae and Pristinidae of phylum Annelida. They are characterized by body segments, clitellum at sexual maturity and characteristic type of species specific dorsal and ventral chaetae. Unlike macrodriles, these microdriles swim freely in the water bodies. Besides bioindicator values, these are important components of aquatic food chain and decomposition cycle. Tubificids are used as bait in aquaculture; tools in toxicity analysis; bioaccumulation bioassays. There are almost 5000 valid species of oligochaetes, about one-third of which are aquatic. The aquatic oligochaetes are the most important micro-invertebrates, adapted to every kind of water such as saltwater, brackish water and freshwater, including small streams, large rivers, marshes, ponds, lakes, springs, and groundwater, with the exception of the primarily terrestrial family Enchytraeidae. Aquatic oligochaetes are more common in wide range of lentic habitat including perennial ponds and paddy fields. It was reported that the diversity and abundance of aquatic oligochaetes depends on algae, rotting materials and physicochemical properties of water. Microdrile species diversity and abundance from wetlands of many parts of India including Karnataka have not been reported, till date, due to lack of identification keys and difficulty in the identification of the species.

The present study aimed to record the species diversity of aquatic oligochaetes (microdrile worms), their distribution pattern, water quality analysis in the selected water bodies of West coast and Western Ghats of Karnataka and to assess the species-specific tolerance to the selected toxic chemicals. Extensive field survey was carried out during July 2012 to December 2015 in the selected water bodies and paddy-fields of different districts of West coast (Dakshina Kannada and Udupi) and two districts of Western Ghats (Uttara Kannada and Shivamogga). Water samples, soil samples and floating materials were screened under the dissection microscope for the microdrile. Random and systematic sampling was done in different timings of the day by collecting one liter of water from the paddy field. However, seasonal sampling was not possible in paddy fields as the paddy would retain water for short time and then it will be dried up in pre harvesting stages.
A systematic seasonal sampling analysis was undertaken in five water bodies (Gurupura (A1), Anekere (B1), Gerusoppa (C1), Ananthpura (D1) and Kotegadde (D5) in the study area. Aquatic oligochaetes were recorded only in 26 out of 355 and 28 out of 150 surveyed water bodies and paddy fields respectively. The diversity and distribution pattern of these microdrile earthworms was analyzed and morphometric details were studied.

A total of 16 species of microdriles were recorded. Of these, 11 species belong to the family Naididae, 5 species to the family Pristinidae. The species recorded include, *Aulophorus furcatus*, *A. moghei*, *A. vagus*, *Allonais paraguayensis*, *A. gwalliorensis*, *Chaetogaster* sp, *Dero digitata*, *D. sawayai*, *D. dorsalis*, *Nais barbata*, *Nais elinguis*, *Pristina longiseta*, *P. proboscidea*, *P. synclites*, *P. menoni* and *P. jenkiniae*. The three species, *Aulophorus furcatus*, *A. vagus* and *Dero digitata* were also collected from the paddy fields. In Venur (A5) only three species such as *A. furcatus*, *A. vagus* and *Dero digitata* were recorded. *Dero dorsalis* and *Allonais paraguayensis* were recorded from 25 and 23 sites (out of 26) respectively. *A. vagus* was recorded from all sites of Dakshina Kannada and is rare in other sites. The species *A. furcatus* was collected from 21 sites of study area. However, the *Chaetogaster* sp. was collected only from 5 sites. Among Pristinidae, *P. longiseta* was recorded from 22 sites.

The recorded species richness and abundance was in the order of Gerusoppa-C1(14 species), Ananthpur-D1(14 species), Gurupura-A1(13 species), Kotegadde-D5 (13 species) and Anekere- B1(12 species). A total of 614 worms in A1 site; 366 in B1 site; 501 in C1 site; 385 in D1 site; 434 in D5 sites were collected during 2012-2014. Therefore, only these water bodies were selected for the systematic seasonal analysis. However, more microdrile worms were collected in the pre monsoon season.

Diversity indices, comparison between seasons, locations and species diversity in relation to water quality was done using appropriate statistical methods. (ANOVA, Fitting regression, Interaction plots, Box plots, Renyi’s diversity–species accumulation curves). Density of microdrile was found to be highest during pre-monsoon followed by monsoon and post monsoon during the study period. First report of microdriles such as *Aulophorus furcatus* and *A. vagus* in the paddy field of study area opens up new area of study in the agricultural practices. The population
density of these worms was five times that of the highest density observed in the eutrophic ponds of the study area. Freshly collected worms were found to be very sensitive to laboratory conditions. Several unidentified species of microdriles were not included in the thesis. Shannon Index, Margelef Index and Simpson Index values were compared for three seasons consecutively two years in Dakshina Kannada, Udupi, Uttara Kannada and Shivamogga districts.

There is a considerable variation in species diversity to both season and organic contents. Eutrophic water bodies were found to be the habitat of microdriles as they depend on either algae or rotting material as main substrata for the decomposition. The species, *A. furcatus*, *A. vagus* and *D. digitata* were found to be abundant in few paddy fields of Moodabidri. *D. sewai*, *D. dorsalis* were found in some wetlands. The species *Allonais paraguayensis*, *Nais barbata*, *Pristina longiseta*, *P. probosclidea*, *P. synclites* and *Aulophorus moghei* were found to be abundant in polluted water bodies. *Allonais gwaliorensis*, *Prestina breviseta*, *Pristina menoni* and *Pristina jenkinia* were found to be abundant in polluted water bodies. *Allonais gwaliorensis*, *Prestina breviseta*, *Pristina menoni* and *Pristina jenkinia* were the most abundant species in the wetlands during the post monsoon season. Results have shown that diversity of aquatic oligochaete is more with organic contents of the wetlands. However, highly polluted water bodies did not have any of these species as they are predominated by mosquito larvae and Chironema larvae. The abundance of oligochaetes varied with the increased concentration of nitrate, phosphate and potassium in the paddy fields.

Differences in mean number of individuals of all species were significant between different water bodies. Between D5 and C1 there is no significant difference. However, between A1, B1 and C1 there is significant difference. B1 has lowest mean and B1 and D5 have greatest significant difference. It is found that the density of microdrile community was highest during pre-monsoon season (S1) when compared to monsoon (S2) and post-monsoon (S3) season. The density was found to be more at D1 during pre-monsoon when compared to other water bodies. Interaction between seasons, species and sampling sites were not found to be statistically significant (p<0.9). It is evident from the results that the oligochaete number increases very significantly as the algal biomass increase in the water bodies (p<0.016) as in pre-monsoon season. The biomass of rotting material and hydrophytes showed weak correlation and is not statistically significant. Negative
correlation was observed between hydrophytes and abundance of microdrile during post monsoon season during the study period (p< 0.591).

Physico-chemical analysis for water samples was assessed and correlation matrix was prepared. Water temperature, dissolved oxygen, potassium, magnesium and sodium were found to be significant parameters influencing the abundance of microdriles in water bodies. However, in 2013-14 electric conductivity and phosphate were also found to be significantly contributing species distribution pattern. Regression on water quality parameters on species indicates that water temperature is highly significant parameter, besides electric conductivity, phosphates and magnesium.

Interaction between seasons, species and locations were not found to be statistically significant as observed from the Interaction plots and also ANOVA results. Box plots were prepared to compare number of individuals of different species collected in different seasons in different sites of localities selected. It is found that the density of microdrile community was highest in S1 (pre-monsoon season) when compared to monsoon and post-monsoon season. Similarly, the density was found to be more in D1 site when compared to other sites of study area during 2013-14. Renyi’s diversity-species accumulation curves were prepared to study richness in different seasons in different sampling sites (A1, B1, C1, D1 and D5). The result indicates that all the species have the same evenness. The D1 has higher diversity than others in all the three seasons.

Few wetlands of the study area showed most stable seasonal population of oligochaetes. Even though wetland was totally dried up in the summer season (April-May) the density of microdrile worm resumed gradually in the post monsoon season, followed by accumulation of decaying leaves and other rotting materials. All parameters were looked carefully to establish the culture systems. The microdrile worms appear to be very sensitive to the insecticide used. The control culture was observed every day for the purpose of observing changes in the activity of worms. There is remarkable fission (asexual reproduction) occurs during favorable conditions like availability of food and suitable temperature 30-32°C. The regeneration of fragmented worm could complete in average 5 to 7 days in favorable culture conditions. Sexual reproduction and cyst formation were noticed in adverse
conditions. Among three species of three different families selected for culture, *Pristina proboscidea* was found to be the pesticide tolerant species in the *in-vitro* conditions. Culture showed positive relation with sunlight, rotting material, 30°C temperature, and dissolved oxygen. In some species negative relation was observed in the presence of chironema larvae, high or very low temperature, absence of light penetrations, BOD, and mosquito larvae. The *Pristina proboscidea* survives even if the fresh water is not added. In comparison with field observation, this can tolerate high BOD, and pollutants in water body. It is the fast moving worm which can tolerate any extreme conditions.

A culture of microdriles was standardized for the purpose of toxicity testing. Different culture systems were prepared by using leaf base of areca-nut, straw and rotting leaves. These systems were maintained for several weeks using natural pond water in the open area where sufficient air and light was available. In the present study, *Aeolosoma hemprichi* was often collected along with other naidids in wetlands. The *in-vitro* culture of this was also successful with algal components and could be maintained for 3 months. The common pesticides used in the paddy field were selected for the *in-vitro* experiments and the LC$_{50}$ values were analyzed. LC$_{50}$ was determined for 96 hours. An attempt has been made to study toxicity by using monocil and phoskill pesticide. The species, such as *A. furcatus* (Fam. Naididae), *Pristina proboscidea* (Fam. Pristinidae) and *Aeolosoma hemprichi* (Fam. Aeolosomatidae) were chosen for toxicity analysis. Pesticides added cultures were maintained at 0.2, 0.4, 0.6 and 0.8mg/l concentration and observed at the interval of 48, 72, 96 and 120 hours. For the period of 96 hours exposure, LC$_{50}$ recorded was 0.2mgL$^{-1}$ for *Aulophorus furcatus* and 0.6mgL$^{-1}$ for *P. proboscidea*. At 120 hours, with 0.4mgL$^{-1}$ concentration of phoskill, *Aulophorus furcatus* showed 100% mortality. Higher LC$_{50}$ value of *A. hemprichi*, used as test organism indicates that polychaetes are more tolerant to monocil and phoskill than oligochaetes. The sensitivity to toxicants in microdriles indicates that they are normally killed by applying pesticides in paddy fields which may affect the decomposition cycle in natural agro-ecosystem. Culture systems established for three species of microdrile worms (*Aulophorus furcatus, Pristina proboscidea* and *Aeolosoma hemprichi*) have shown that the LC$_{50}$ for the selected pesticides (monocil and phoskill) was in the order of *A. hemprichi* $>$ *P. proboscidea* $>$ *A. furcatus*. 
The results obtained based on the work carried out as per the objectives has led to get an insight into the diversity and distributions of aquatic oligochaetes in the selected study area. The extensive survey conducted in the lentic water bodies of the study area has recorded 16 species of microdrile earthworms. This forms the baseline data on the distribution of aquatic oligochaetes of the region. The study has revealed that considerable increase in the diversity was found in pre-monsoon season. Aquatic oligochaetes are widespread in Western Ghats and West coast. This may be due to increased organic content of water, reduced water level, increased algae, rotting material, and availability of sunlight. In general, the chemical parameters such as $K^+$, $PO_4^{3-}$, $NO_3^-$, $Ca^{2+}$, $Mg^{2+}$ and $Na^+$ showed highest correlations among themselves in all sites when compared to other physical parameters. Extensive cattle population and dropping of dung probably increase concentration of $K^+$, $PO_4^{3-}$, $NO_3^-$. It has been found that even after extensive field work microdriles were not found in pesticide sprayed paddy fields. It indicates that microdriles are very sensitive to concentration of pesticide that is used in the paddy fields. It was possible to study only few water bodies for the occurrence of aquatic oligochaetes and their bio-indicator properties. Similar studies needs to be undertaken to understand the species specific habitat requirements and their possible ecological role in ecosystem sustenance.

The culture technique established can also become the basis for aquaculture practices where baits of this type of worms are used. Macrodriles are used as bait in capture fisheries. Like, *Tubifex* sp. which is most extensively used as food in culture fisheries. Even though, Western Ghats and West coasts have more than thousand wetlands, research and conservation aspects of wetlands are completely ignored. Major threats to these water bodies in general and biodiversity in particular is noticed due to human activities such as fishing, unregulated discharge of sewage and domestic wastes leading to eutrophication and extensive growth of aquatic weeds. Since majority of the wetlands of Western Ghats and West coast belong to the category of government land, Ministry of Environment and Forest department must look into implementation of stringent conservation policies.