IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 10, Issue 12 Ver. III (Dec. 2016), PP 64-68
www.iosrjournals.org

Oligochaete Community Structure During Different Agricultural Seasons in Kole Paddy Fields, Vembanad Kole Wetland, India

Vineetha S
Department of Marine Biology, Microbiology & Biochemistry, School of Marine Sciences, Cochin University of Science and Technology, Fine Arts Avenue, Kochi-682016, Kerala, India

Abstract: *Oligochaetes influence nutrient dynamics in paddy fields, the largest freshwater ecosystems. Oligochaete community structure in seasonal paddy fields during flooded and paddy cultivating seasons in Kole wetlands, a part of Vembanad kole wetlands (a Ramsar site) was analyzed. Oligochaete species of the families Naididae, Tubificidae and Lumbriculidae were present. Aulodrilus pluriseta, Pristinella jenkinae, Branchodrilus semperi, Aulodrilus pigueti, Pristinella minuta and Aulodrilus sp. were the species common in both the seasons. The ANOSIM of oligochaete species revealed that the dissimilarity in oligochaete compostion was not very strong between both seasons. The difference in oligochaete abundance was also not significant between the seasons, though flooded season showed a higher abundance. The availability of more area under inundation, thus providing more habitable area for oligochaetes would have resulted in a higher abundance in flooded season, whereas in paddy season, the habitable area was less due to compartmented nature of bottom of paddy fields. In spite of the reduced abundance, a higher species richness and diversity was observed in paddy season. Irrespective of the agricultural operations subjecting the organisms to drastic conditions, a comparable oligochaete structure existed in flooded and paddy seasons, implying the potential for long term agrarian livelihood of this wetland.*
Keywords: *flooded season, paddy fields, oligochaetes, Vembanad Kole wetland.*

I. Introduction

Paddy fields, considered as man managed temporary wetlands, existed since the beginning of organized agriculture as rice had been a chief food source since 2500 B.C.[1,2]. Each year the paddy fields undergo severe transformations due to agricultural operations. In seasonally flooded paddy fields, the system transform from an open, deep, littoral environment in flooded season to a shallow vegetated system in paddy cultivating seasons, through a series of operations, subjecting the inhabitant organisms to drastic conditions. The aquatic fauna plays a major role in nutrient recycling. Whether as primary or secondary consumers, animals excrete inorganic and organic forms of nitrogen and phosphorus, and facilitates the exchange of nutrients between soil and water. Among aquatic organisms, benthic oligochaetes have received special attention, as their movement between the reduced soil and the flood water enhances soil porosity thus enhancing nutrient translocation and mineralization. Tubificidae transport the components of photosynthetic aquatic biomass (cyanobacteria, microalgae and aquatic macrophytes) and their breakdown products from the surface to the deeper soil layer thus providing nutrients to the rice plants [3]. However their influence on nutrient dynamics was found to be proportion to its densities. Despite the recognized role of aquatic oligochaetes in maintenance of soil fertility in wetland paddy fields, the information on their ecology remained scarce [4,5].

This study analyzed the oligochaete community structure in seasonal paddy fields during flooded and paddy cultivating seasons in Kole wetlands, a part of Vembanad kole wetlands, a Ramsar site. Kole wetlands are among the water-logged, paddy cultivating areas in Kerala; and were under rice cultivation for the past 200 years since the erstwhile Maharaja permitted to reclaim the wetland into paddy fields in the early 18th century [6]. They were renowned for its high rice production, even the term Kole in Malayalam (the regional language in Kerala, India) means ‘bumper yield of high returns in case flood does not damage the crops’ [7]. Even though studies has been done on paddy field benthic community in different countries, there is a lacuna in the literature available from benthic fauna in paddy fields even though India stands first in area under rice cultivation, second in rice production and has an agricultural based economy [8].

II. Materials and Methods

II.1. Study area

The Kole lands are saucer shaped tracts, lying 0.5 to 1.5 m below the mean sea level, spread over Thrissur and Malappuram districts of Kerala extending from Northern bank of Chalakkudy river in the South to the Southern bank of Bharathappuzha river in the North. The intrusion of salt water to the paddy fields is prevented by Viyyam dam which is situated at the downstream of end of Kole lands. The Kole lands are assumed to be lagoons formed by the recession of the seas centuries back. A shallow portion of the sea along the western periphery of the main land was isolated and they were gradually silted up during rains making the lagoons shallow [9]. The farmers then bunded the fields, dewatered and raised rice in summer months. Though the main crop is *Punja* (Summer crop, December/January- April/May), an additional crop (*Kadumkrishi*) are raised in Kole wetlands [10]. During the rains, the inflow into the basin submerges the kole areas. Through the flooded season, the area acts as fresh water ecosystem supporting indigenous fishes thus providing nutrition and an alternative source of income for farmers during monsoon period which is experienced as lean period for farmers.

The study area, with an area of 100 acres, is a part of the Ponnani Kole lie in between Maranchery and Veliyamkodu panchayats (a village council is called panchayat) in Malappuram district (Fig.1). From July to December 2010, the study area was flooded due to the South West Monsoon (June to September). By the end of the north east monsoon (October to December), water from the area was pumped out and paddy cultivation was begun by January. Dewatering was done by an indigenous centrifugal pumping device (*petti* and *para)* after protecting the paddy fields (*Padavu* or *Padashekharam*) with permanent or temporary earthen bunds (*Mattoms*). The crop was harvested by the end of May, soon after which the field gets flooded due to the South West Monsoon.

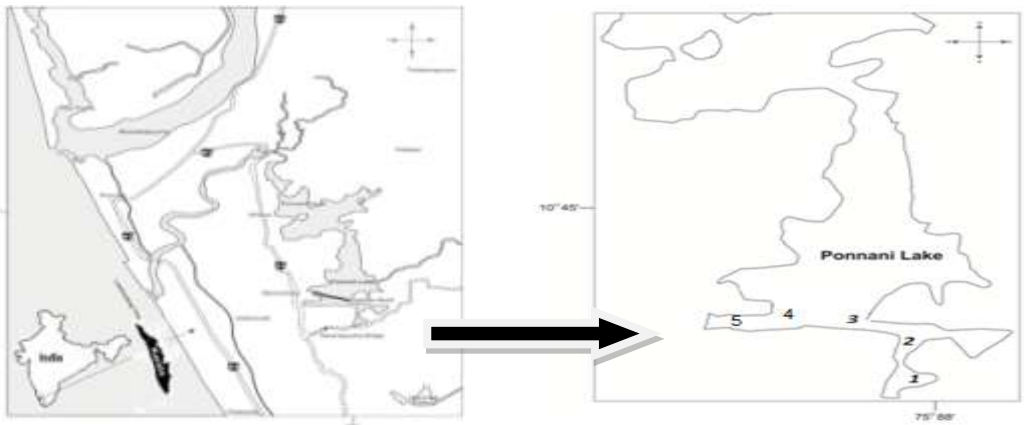

Fig.1. Location of sampling stations in Maranchery Kole paddy fields

II.2. Sampling procedure and methods

The field sampling was carried out from five sampling stations for 11 months including a submerged/flooded season extending from July to December 2010 and a complete crop season '*punja*' extending from January to May 2011 on a monthly basis for the study of oligochaete species and environmental parameters.

Rain fall data was collected from the Indian Meteorological Department website (imd.gov.in). During flooded season water samples were collected using a Niskin water sampler (Hydrobios 5 L) and during paddy season, as the water body was shallow (average depth 0.39m), water samples were collected using a locally fabricated shallow water sampler of 1 liter capacity. The samples were stored in plastic containers and kept frozen till analysis. The sediment samples for the analysis were collected using a Van Veen grab of size $0.45m^2$. Temperature was measured in the field using a standard degree centigrade thermometer of 0°C to 50°C range and 0.l°C accuracy. pH was measured using Systronics digital pH meter model MK VI. Dissolved oxygen was analyzed by modified Winkler method [11]. Organic carbon was determined by Walkley - Black method, then converted to organic matter by multiplying with Van Bemmelen factor of 1.742 [12]. Particle size was analyzed using particle analyzer SympatrecT 100 laser diffraction granulometer, made in Germany.

Sediment samples in replicate were collected for the analysis of macrobenthos using a VanVeen grab of size $0.45m^2$. The samples were washed in the field itself through a sieve of mesh size 500 µm and those that were retained in the sieve were collected and preserved in 5% formalin [13,14]. The organisms were separated into different taxonomic groups. Oligochaetes were identified up to species level by temporarily mounting the specimens using Amman's Lactophenol (Phenol, Lactic acid, Glycerol, and water in the ratio of 1:1:2:1) using taxonomic keys [15.16].

II.3. Statistical Analysis

One way ANOVA was used to determine the significant difference in environmental parameters and numerical abundance of oligochaetes between the flooded season and paddy season using SPSS 16.0. Abundance data was square root transformed to meet the ANOVA assumptions. The data on oligochaete species was subjected to multivariate and univariate analysis by using the Primer software version 6.0 [17]. ANOSIM was used to analyze the similarity of oligochaete assemblages between flooded season and paddy season. The univariate indices of diversity such as species richness by Margalefs index [18], species evenness by Pielou's index [19], species diversity by Shannon index [20] (Shannon Wiener, 1949) and species dominance by Simpson's index [21] were calculated for flooded and paddy seasons.

111. Results and Discussions

Significant difference existed between flooded and paddy seasons when many of the physico chemical parameters were analyzed. Flooded season existed in monsoon and post monsoon, whereas paddy season in pre monsoon seasons, a significant difference in rain fall was observed (ANOVA $F_{5,27}$=11.37 $P< 0.01$). In flooded season, rain fall was 290±160 mm and in paddy season it was 49± 52 mm. The most variable physical parameter was depth, that showed a significant variation among the two seasons (ANOVA $F_{5,27}$=53.26 $P< 0.01$). Depth in flooded season was 2.54±1.01m and paddy season was 0.39±0.08 m. Dissolved oxygen in flooded and paddy seasons were 6.54±1.14 and 6.37±1.70 mg/L respectively. Sediment temperature in flooded and paddy seasons was 26.91±1.01 and 27.22±1.6 °C respectively. A significant difference in sediment pH was recorded in flooded and paddy seasons ANOVA $F_{5,27}$=4.25 $P< 0.01$); values being 6.68±0.2 and 6.35±0.58 respectively. Sediment oxidation reduction potential (Eh) between the seasons showed a significant difference between them (ANOVA $F_{5,27}$=3.11 $P< 0.05$). Flooded season was more reduced (-249.60±3.45 mV) than paddy season (-222.41±4.01 mV). Moisture content recorded from flooded and paddy seasons were 28.5 and 26.4% respectively. Organic matter content in flooded and paddy seasons were 3.73±1.05 and 3.95±0.78% respectively, no significant variation was observed among the two seasons. Available nitrogen in flooded season was 0.02±.005 and paddy season was 0.01±0.006%. Available phosphorus in flooded and paddy seasons was 0.98 ±0.60 and 0.34 ±0.17 ppm respectively, the difference in available phosphorus was significant (ANOVA $F_{5,27}$)=7.77 $P< 0.01$. Clay, silt and sand in flooded season was 28.82±4.76, 48.74±7.47, 22.43±6.62% respectively and that in paddy season was 26.45±5.50, 46.46±10.49 and 46.42±10.49% respectively.

Oligochaete species present in the area belonged to the families Naididae, Tubificidae and Lumbriculidae. While Naididae and Tubificidae were present in both the seasons, Lumbriculidae was restricted to flooded season. In wet phase, 12 species of oligochaetes were present (Fig.2) whereas in paddy phase, only 9 species of oligochaetes were present (Fig.3). *Aulodrilus pluriseta* (Piguet, 1906), *Aulodrilus sp.*, *Pristinella jenkinae* (Stephenson, 1931), *Branchodrilus semperi* (Bourne, 1890), *Aulodrilus pigueti* (Kowalewski, 1914) *and Pristinella minuta (*Stephenson, 1914) were the oligochaete species common to both the seasons. *Lumbriculus variegates* (Muller, 1773), *Haemonais waldvogeli (*Bretscher, 1900), *Aulophorus hymnae* (Naidu, 1963), *Pristinella menoni* (Aiyer, 1929), *Pristina breviseta* (Bourne, 1891) and *Nais sp.* were present only in flooded season whereas *Stephansonia trivandriana* (Aiyer, 1926), *Branchiodrilus hortensis (*Stephenson, 1910) and *Homochaeta* sp. were present in paddy seasons. In flooded season, *Aulodrilus pluriseta* (50%) was the most abundant species followed by *Branchodrilus semperi* (11%) and *Pristinella jenkinae* (11%). In paddy season, the most abundant species was *Aulodrilus sp.* (23%) and *Aulodrilus pluriseta* (18%).

The information on oligochaete species from paddy fields was not copious though it was one of most important organism for maintaining fertility in paddy fields. In winter-flooded and organically managed paddy field of Miyagi, Japan the major species were *Limnodrilus socialis* and *Branchiura sowerbyi* [22]. In Philippines *Limnodrilus hoffmeisteri* and *Branchiodrilus sowerbyi* of the family Tubificidae were the most abundant [23], which was similar to observations from Japan. In Milan, Italy also *Branchiura sowerbyi* and immature tubificids were the most abundant oligochaete species [24]. Oligochaeta, such as Tubificidae, Naididae and Enchytraeidae, are a major component of soil fauna in wetland rice field conditions in Japan [25]. In India, the earthworm *Darwida willsi* dominated the paddy fields [26]. In Chapra, Bihar, India the families Aeolosomatidae, Tubificidae and Megascolecidae constituted oligochaete fauna [27]. A recent study from the paddy fields of Dakshin Kannada, India revealed a very high density of *Aulophorus furcata* of the family Naididae [28].

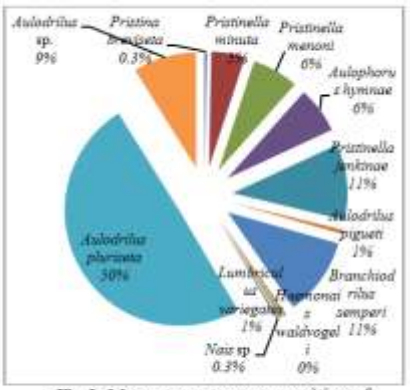

Fig.2. Mean percentage composition of oligochaete species during wet season

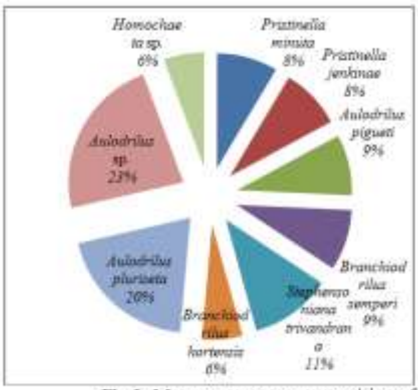

Fig.3. Mean percentage composition of oligochaete species during paddy season

The ANOSIM of oligochaete species pattern between paddy and wet phase also showed that the dissimilarity in oligochaete composition was not very strong (R-0.091 p=4.2%). Negative R values indicated that dissimilarities within the seasons were greater than dissimilarities between seasons. The survival strategy used by oligochaetes by forming cysts etc. would have ensured the presence of oligochaetes survive through the unfavorable and dry conditions during the transformation between flooded and paddy seasons. Being aquatic worms, oligochaetes were benthic crawlers (passive colonizers), so due to the reduced dispersal ability of oligochaetes, they would not have escaped to other areas. In spite of difference in the physical structure between the phases, the oligochaete composition did not show a significant difference between them. Furthermore, the less prominent niche specialization of oligochaetes proved by many studies could also be a reason for the similarity in species structure [29,30]. Moreover, the comparison was made in the same site in a different temporal scale; so a very different oligochaete composition among them was not expected.

Oligochaete abundance was highest in flooded phase (263±473 ind./m^2) than paddy season (102±161 ind/m^2), the difference in abundance was not significant (Fig.4). During flooded season, the area under inundation was more. The increase in habitable area could result in an increase in the number of organisms [31]. Unlike the bottom of the channel, bottom of the paddy field was compartmented by paddy root structures providing insufficient space for the proper development of benthic fauna, could be a probable reason; a similar report was from Chapra, Bihar where the total average number of benthic macrofauna of paddy fields was less in contrast to the benthos from adjacent ponds [27]. Apart from the difference in the habitable area, an important factor that differed among both the seasons was the presence of fish. Flooded season was characterized by the presence of fishes whereas paddy season was not. Fishes, by grazing on the oligochaete population have been found capable of reducing its population in a rice field by 80% [32].

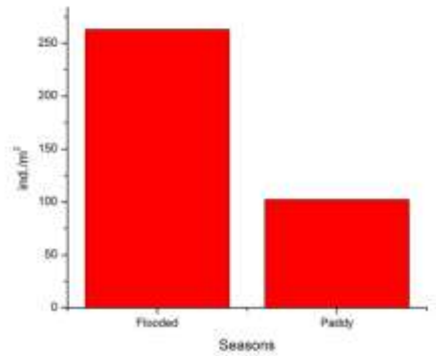

Fig. 4. Mean variation in oligochaete abundance during flooded and paddy seasons

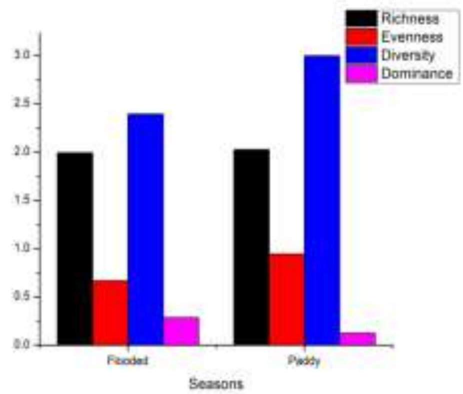

Fig. 5. Diversity indices of oligochaete species during flooded and paddy seasons

Though there was a marked reduction in abundance of oligochaetes in paddy season, species richness (2.026) and diversity (2.996) were more in paddy season (Fig.5). When the reduced habitable area due to paddy plantation reduced the number of oligochaetes in paddy fields, due to the same reason the oligochaetes would have utilized the available habitable open areas as a refuge, thereby ensuring a fairly high diversity and richness in areas free from paddy roots. This scenario could be viewed analogous to the increased benthic richness observed in available water patches, when the rest of the substratum are dry, due to the usage of water patches as refuge by the benthic organisms [32].

IV. Conclusion

The concept of ecoagriculture or utilizing the biodiversity for enhancing agricultural productivity is gaining momentum especially in a context when the ill effects of agrochemicals on the ecosystem are revealed gradually. In this regard, the studies on oligochaete community structure in paddy wetlands are important due to its potential to enhance the fertility of the paddy fields. Proper management strategies could enhance the population of oligochaetes, thus the usage of chemical fertilizers and weedicides can be reduced. It is particularly beneficial for small scale farmers, who need to optimize the available limited resources due to financial or infrastructural constraints.

Acknowledgements

The author is thankful to the Head of the Department of Marine biology, Microbiology and Biochemistry, Cochin university of Science and Technology for providing necessary facilities. The author is also thankful to University Grants Commission for the research fellowship. This study was a part of the research project funded by Kerala state Biodiversity Board, the author is thankful to them.

References

[1]. Lupi D, Rocco A, Rossaro B. 2013. Benthic macroinvertebrates in Italian rice fields. Journal of Limnology 72(1):184-200.
[2]. Edirisinghe JP, Bambaradeniya CNB. Rice fields : an ecosystem rich in biodiversity. Journal of National Science Foundation Sri Lanka 34(2): 57-59.
[3]. Lavelle P., Brussard L., Hendrix P. F. 1999. Earthworm management in tropical agroecosystems. Oxford University Press, Oxford. 300 pp.
[4]. Roger PA, Kurihara Y. 1988. Floodwater biology of tropical wetland ricefields. In: Int Symp Paddy Soil Fertility. International Soil Science Society, The Hague 275 -300.
[5]. Kurihara Y. 1989. Ecology of some rice fields in Japan as exemplified by some benthic fauna, with notes on manage- ment. Int. Revue ges. Hydrobiol 74: 507-548.
[6]. Anonymous. 1989. Scheme for studying the possible changes in the ecosystem consequent on the conservation of Thannermukkam Bund, Thrissur, Kerala. Kerala Agricultural University.
[7]. Johnkutty I, Venugopal VK. 1993. Kole wetlands of Kerala, Kerala Agricultural University, Thrissur 68PP.
[8]. Balachandran PV. 2007. Rice scenario of Kerala and the future strategies. Proceedings of XIX Kerala Science Congress, Kannur, Kerala 22-32 pp.
[9]. Kurup PG, Varadachar VVRG. 1975. Hydrography of Purakkad mud bank region Indian Journal of Marine Sciences 4:18-20.
[10]. Raj N, Azeez PA. 2009. The Shrinking Rice Paddies Of Kerala, The India Economy Review Volume VI:176-183.
[11]. Strickland JDH, Parsons TR. 1972. A practical handbook of seawater analysis. Bull Fish Res Bd Can, 2nd Edn vol 167:310pp.
[12]. Jackson M L. 1973. Soil chemical analysis, Printers- Hall India Ltd, New Delhi.
[13]. Holme NA, Mc Intyre AD. 1971. Methods for study of Marine Benthos, IBP Hand book No.6, Blackwell Scientific Publications.
[14]. McIntyre AD, Antasious Eleftheriou. 2005. 3rd edn. Methods for the study of Marine benthos. Blackwell Scientific Publications.
[15]. Brinkhurst RO, Jamieson BGM. 1971. Aquatic Oligochaeta of the World. Oliver and Boyd, Edinburgh.
[16]. Naidu KV. 2005. The Fauna of India and the Adjacent Countries-Aquatic Oligochaeta. Zoological Survey of India, Kolkata.
[17]. Clarke, K.R., Gorley, R.M., 2006. PRIMER v6: user manual/tutorial. PRIMER-E, Plymouth.
[18]. Margalef R. 1968. Perspective in ecological theory. University of Chicago Press, Chicago: 111.
[19]. Pielou EC. 1966. Shannon's formula as a measurement of specific diversity and its use and misuse. American Naturalist 100(914):463-465.
[20]. Shannon C.E., and Weaver W., 1949. The Mathematical theory of communication. University of llinois Press, Urbana, Illinois 117 pp.
[21]. Simpson E.H., 1949. Measurement and diversity. Nature 163:688
[22]. Ito T and Hara K 2010. Impact of Tubifi cid Worm on Nutrient Dynamics in Paddy Field JIFS, 7 : 47-50.
[23]. Simpson IC, Roger PA, Oficial R, Grant IF. 1993. Impacts of agricultural practices on aquatic oligochaete populations in ricefields. Biol Fertil Soils 1627-33.
[24]. Rossaro B, Marziali L, Cortesi P 2014. The Effects of Tricyclazole Treatment on Aquatic Invertebrates in a Rice Paddy Field. Clean – Soil, Air,Water 42 (1), 29–35
[25]. Yokota H, Kaneko N (2002) Naidid worms (Oligochaeta, Naididae) in paddy soils as affected by the application of legume mulch and/or tillage practice. Biol Fertil Soils 35:122–127
[26]. Senapati BK, Biswal J, Sahu SK, Pani SC. 1991. Impact of malathion on Darwidu willsi Michaelsen, a dominant earthworm in rice fields. Pedobiologia 35:117- 128.
[27]. Ojha NK, Pandey MK, Yadav RN. 2010. Studies on macrobenthic community of paddy field of rural Chapra. Bioscan: Special issue 2:579-585.
[28]. Hegde PR, Sreepada KS. 2014. Reports on aquatic oligochaetes (Naididae) in paddy fields of Moodabidri Taluk, Dakshina Kannada, South India. Journal of entomology and zoology studies; 2 (2): 101-107 ISSN 2320-7078.
[29]. Verdonschot PFM, Higler LWG. 1989. Macroinvertebrates in Dutch ditches: a typological characterization and the status of the Demmerik ditches. Aquatic Ecology 23:135–142.
[30]. Verdonschot PFM. 1999. Micro-distribution of oligochaetes in a soft-bottomed lowland stream (Elsbeek; The Netherlands) Hydrobiologia 406:33–47.
[31]. Sommer B, Horwitz P. 2009. Macroinvertebrate cycles of decline and recovery in Swan Coastal Plain (Western Australia) wetlands affected by drought-induced acidification Hydrobiologia 624:191–203.
[32]. Cagauan AG. Overview of the potential roles of pisciculture on pest and disease control and nutrient management in rice fields. In:Seminar on the management of integrated ecosystems in tropical areas. Technical Centre for Agriculture and Rural Co-operation (CTA), Royal Academy of Overseas Sciences (Brussels); 1994, 203-244.