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Observation of the seasonal changes in the physical, chemical and nutrient parameters of three temple ponds at Thirupparankundram near Madurai, Tamilnadu, India.

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Abstract

Monthly changes in 15 surface water physical, chemical and nutrient parameters of three freshwater temple ponds at Thirupparankundram, Madurai. Tamil Nadu, India were recorded for a period of three years from September 2009 to August 2012. The values recorded for most of these parameters were within the permissible limits and were found to be influenced mainly by the seasonal changes and altitudinal variations.

Keywords: Physical, chemical and nutrient parameters, Temple pond, Thirupparankundram.

Introduction

Fresh water has become a scarce commodity due to over exploitation and pollution of water. Increasing population and its necessities have lead to the deterioration of surface and sub surface water. Limnology plays an important role in decision making processes for problems like dam construction, pollution control and aquaculture practices (Muley and Gaikwad, 1999). Freshwaters of the world are collectively experiencing markedly accelerating rates of qualitative and quantitative degradation (Carpenter *et al.*, 2011). Stagnant water bodies have more complex and fragile ecosystems in comparison to running water bodies as they lack self cleaning ability and hence, readily accumulate greater quantities of pollutants. Increased anthropogenic activities in and around the water bodies damage the aquatic systems and ultimately properties of water. Human populations continue to abuse water resources at a large scale. So efforts to conserve

these resources are a present and urgent need. Several limnological studies on freshwater temple ponds have been made in India in recent times by Thirugnanamoorthy and Selvaraju (2009), Jemi and Balasingh (2011), Tidame and Shinde (2012), (Banita *et al.*, 2013) and (Padate *et al*., 2014). The present study, in these lines makes an attempt to find out the seasonal changes in the physical, chemical and nutrient parameters in the surface water of the three tropical perennial freshwater temple ponds in Thirupparankundram with the focus on the effect of size, altitude and human interference on their water quality.

Study Area

Thirupparankundram, is a town located about six kilometers south-east of Madurai. It is a historical holy place known for the famous temple of Lord Subramanya situated at the base of the hillock and has a heavy inflow of pilgrims regularly for worship from all over the state and tourists from other states of India and abroad. There are three ponds associated with this temple, one on the top of the hillock named Kasi theertham, the second one within the temple, Lakshmi theertham and the third one outside the temple, Saravana poigai. Geographically, these ponds are associated with a hillock located at 9°54'N; 78°7'E from the base at 131MSL measuring a total height of 1056 feet. All the three ponds receive rain water which drains out from hillock and this is the only source of water in these ponds. The ponds are used for bathing, washing and recreational activities by pilgrims. Interestingly, these three ponds which are at the same geographical location and fed by rain water during the monsoon showers differ in their size, altitude and human impact. This provides a unique opportunity to study the seasonal changes in the physical, chemical and nutrient parameters in the surface water of the three ponds.

Materials and Methods

Sampling of water was done for every month and analyzed on the day of sampling. Samples were collected between 6 and 8 a.m. on all days with the view of ensuring uniformity. Observations were made for the temperature of air and surface water using centigrade thermometer, humidity using hygrometer and pH using pH paper on the spot itself. The physical parameters are the non-living components in an ecosystem concerned with the medium and climate. The following are the physical parameters observed in the present study. The colour of the pond water was noted down by simple visual observation both in field and in the filtered

water sample. The special odour of the water sample, if any, was noted down by the smell at the time of observation in the vicinity of the pond. The temperature of the water and air were recorded with the help of standard centigrade thermometer at °C at the time of visits. pH of the water sample was recorded with the help of standard pH papers on the spot. Later it was also measured in the laboratory by using pH meter (ELICO; L1120, India) following the method of APHA (1995). The total suspended material in the water samples was estimated gravimetrically in mg/l. and considered as an indirect measure of the turbidity. This was done by filtering 100ml of well mixed water sample through pre-weighed (w1) filter paper and weighing (w2) the same in an electronic balance at 0.01 mg accuracy after drying it in hot air oven adjusted at 103°C overnight for evaporation. This is then considered to represent the Total suspended solids (TSS) in mg/l= (w2-w1) and may be taken as an indirect measure of turbidity of the water (Kodarkar, 1992). The total suspended material in the water samples was estimated gravimetrically in mg/l. and considered as an indirect measure of the turbidity (Kodarkar, 1992). The following chemical parameters were observed in the present study following standard procedures. The dissolved oxygen content of the water sample was estimated by the modified Winkler's method of Strickland and Parsons (1972) in APHA (1995). The free CO_2 content of samples was determined following (Mackereth *et al.,* 1978). The carbonate and bicarbonate alkalinity of water sample was found out by neutralizing the sample with Std. H_2SO_4 following (Adoni *et al.,* 1985). The salinity of the sample was estimated by titrating a known volume of the sample against the standard Harvey's Silver nitrate (0.014N) using 0.5ml of Potassium chromate as the indicator (Adoni *et al.,*1985). The total Hardness of water sample was estimated titrimetrically using standard EDTA solution as the titrant and Erichrome Black – T as indicator. The calcium hardness in water sample was also found out titrimetrically using the standards EDTA (0.01N) solution. The magnesium hardness in the water sample was calculated by subtracting calcium hardness from total hardness. The nutrient parameters are those chemicals that serve as nutrients to the living components in the ecosystem. The following nutrient parameters were considered in this study. The chlorides in water samples were estimated titrimetrically following (Mackereth *et al.,* 1978). Phosphates as the orthophosphate content in water was calculated spectrophotometrically following the Ammonium molybdate method as described in (Adoni *et al.,* 1985). The sulphate content in water sample was calculated by turbidimetric method as

described in (Adoni *et al.*, 1985). Nitrate content was estimated following the Phenol di-sulphonic acid method (Wilcox and Hatcher, 1950).

Result and Discussion

The observations made on the seasonal changes in the physical, chemical and nutrient parameters in the water samples collected from the three ponds for the present study revealed significant variations both with reference to the seasons and human impact. The month wise analysis of the rainfall data for this region enabled the recognition of three distinct seasons for the interpretation of the observations in the present study as Monsoon (September-December), Post-monsoon (January-April) and Pre-monsoon (May-August) seasons respectively. In any aquatic ecosystem, the abiotic physico-chemical environment has profound influence on its biotic components. It controls biodiversity, biomass and distribution of biotic communities. The observations made on the seasonal changes in the physical, chemical and nutrient parameters in the water samples collected from the three ponds for the present study revealed significant variations both with reference to the seasons and human impact. In the present observation, the pond water was apparently colourless during monsoon and post-monsoon seasons but was slightly greenish during the pre-monsoon season. With regard to odour, the water in all the three ponds was not having any obnoxious smell throughout the study period. (Rameshbabu and Selvanayagam, 2013) observed the appearance of water samples as clean and clear throughout the study period except at two locations where they appeared turbid and green during post-monsoon and summer. The physical parameters revealed that the pond waters were apparently colourless and slightly greenish but not having any obnoxious smell throughout the study period. The air temperature ranged from 25.6˚C to 38.8˚C in Kasi theertham, from 21.4˚C to 39.5˚C in Lakshmi theertham and from 21˚C to 40.3˚C in Saravana poigai. The surface water temperature ranged from 21.6˚C to 33˚C in Kasi theertham, from 19.3˚C to 37.7˚C in Lakshmi theertham and from 16.5˚C to 37.7˚C in Saravana poigai (Fig.1-9). The high temperature during day time is due to high solar radiation. The low temperature in winter months is because of the cool conditions prevailing throughout the day when compared to summer season (Ayyanna and Narayudu, 2013). Sharma *et al.*, 2013 reported that in the temple pond in Birpur the water temperature varied in accordance with the air temperature and it ranged from 11.63˚C (December) to 33.0˚C (May). The pH ranged from 6.7 to 8.7 in Kasi theertham, from 6.9 and 9.1 in Lakshmi theertham and from 7.1 to

9.5 in Saravana poigai (Fig.10-12). The pH of lake water that ranged between 7.2 and 7.8 was alkaline and hence favourable for the growth of the planktons and fishes (Lendhe and Yeragi, 2004). The Total Filterable Residue (TFR) present in the surface water of the ponds ranged from 243mg/l to 811mg/l in Kasi theertham, from 462mg/l to 682mg/l in Lakshmi theertham and from 230mg/l to 521mg/l in Saravana poigai (Fig.13-15). (Jemi and Balasingh, 2011) observed the total dissolved solids to be more during summer and less during monsoon. Similarly the total filterable residue was reported to range from 316mg/l to 646mg/l with the highest value of TFR (646mg/l) recorded during summer in the study carried out by (Rameshbabu and Selvanayagam, 2013).

The chemical parameters showed that the alkalinity observed in the surface waters of the ponds during the study period ranged from 5mg/l to 32mg/l in Kasi theertham, from 14mg/l to 87mg/l in Lakshmi theertham and from 23mg/l to 188mg/l in Saravana poigai (Fig.16-18). Jemi and Balasingh, 2011 observed the total alkalinity to range from 85.25 to 139.75mg/l (Padmanapapuram temple pond) and 68.75 to 114.50mg/l (Parvathipuram temple pond) during summer and monsoon season respectively. (Amshadevi *et al.,* 2013) noticed the total alkalinity to range from 92.5 to 255ppm in a pond. The water bodies having total alkalinity above 50mg/l can be considered productive and this present finding showed that all the three ponds as productive during most part of the year (Moyle, 1946). The free carbon di-oxide ranged from 1.6mg/l to 27.6mg/l in Kasi theertham, from 6.9mg/l to 61.6mg/l in Lakshmi theertham and from 7.7mg/l to 73.7mg/l in Saravana poigai (Fig.19-21). Jemi and Balasingh, 2011 noticed ponds to exhibit maximum carbon di-oxide as 6.33mg/l (Padmanapapuram temple pond) during summer and low concentration of 3.95mg/l (Parvathipuram temple pond) during monsoon season. Carbonates showed their absence in November and January and this was due to the presence of free carbon dioxide during this period. An increase in the values of bicarbonates was recorded in summer and monsoon seasons (Sharma *et al.,* 2013). Aquatic vegetation and phytoplankton require carbon di-oxide for photosynthetic activity. The dissolved oxygen ranged from 2.12mg/l to 4.9mg/l in Kasi theertham, from 3.12mg/l to 6.82mg/l in Lakshmi theertham and from 0.41mg/l to 6.84mg/l in Saravana poigai (Fig.22-24). Joshi and Bhalla, 2012 observed the reduction of dissolved oxygen (DO) as a result of sewage outfall in to the river. Rameshbabu and Selvanayagam, 2013 reported DO values to range from to 10.2mg/l. The highest value of

DO (10.2mg/l) was recorded during premonsoon and lowest value (7.8mg/l) was recorded during post-monsoon. The salinity ranged from 1mg/l to 19mg/l in Kasi theertham, from 14mg/l to 39mg/l Lakshmi theertham and from 19mg/l to 51mg/l in Saravana poigai (Fig.25-27). Ayyanna and Narayudu, 2013 reported that in winter months due to low temperature the salinity is less (0.31mg/l) Land during spring season. When the temperature is high, the salinity is more (0.42mg/l). This is due to evaporation of water during hot seasons. The total hardness ranged from 20mg/l to 98mg/l in Kasi theertham, from 110mg/l to 198mg/l in Lakshmi theertham and from 77mg/ to 247mg/l in Saravana poigai (Fig.28-30). Uchchariya and Saksena, 2012 reported the average total hardness of water in their study at Tighra Reservoir to be as 50.10±1.92mg l^{-1}. The calcium hardness ranged from 4mg/l to 25mg/l in Kasi theertham, from 37mg/l to 107mg/l in Lakshmi theertham and from 83mg/l to 157mg/l in Saravana poigai (Fig.31-33). Sharma *et al.*, 2013 had observed the calcium content in the temple pond in Birpur to show a maximum of 40.90mg/l and a minimum of 16.43mg/l in the months of November and February respectively. The magnesium hardness ranged from 0.41mg/l to 17mg/l in Kasi theertham, from 12mg/l to 34mg/l in Lakshmi theertham and from 3mg/l to 18mg/l in Saravana poigai (Fig.34-36). Rameshbabu and Selvanayagam, 2013 observed the highest value of magnesium as 25mg/l and lowest value as 12mg/l in monsoon season at Kolavoi Lake.

The nutrient parameters showed that the chloride level ranged from 1mg/l to 9mg/l in Kasi theertham, from 5mg/l to 27mg/l in Lakshmi theertham and from 5mg/l to 31mg/l in Saravana poigai (Fig.37-39). Rameshbabu and Selvanayagam, 2013 observed the chloride ions to range from 21mg/l to 162mg/l at Kolavoi Lake. The phosphate level ranged from 0.1mg/l to 0.9mg/l in Kasi theertham, from 0.3mg/l to 3.1mg/l in Lakshmi theertham and from 2.8mg/l to 9.7mg/l in Saravana poigai (Fig.40-42). Narayana *et al.*, 2008 recorded the phosphate to range between 0.004mg/l to 0.014 mg/l in Anjanapuram reservoir near Shikaripur, Shimoga District, Karnataka. The sulphate content ranged from 1mg/l to 5mg/l in Kasi theertham, from 1mg/l to 5.9mg/l in Lakshmi theertham and from 2.1mg/l to 7.9mg/l in Saravana poigai (Fig.43-45). Harney *et al.*, 2013 observed the values of sulphate recorded as1.0 mg/l to 3.80 mg/l in Kanhala pond, 0.84 mg/l to 2.10 mg/l in Pindavani pond and 1.00 mg/l to 1.82 mg/l in Malhara pond. The nitrate ranged from 10mg/l to 30mg/l in Kasi theertham, from 19mg/l to 39mg/l in Lakshmi theertham and from 31mg/l to 79mg/l in Saravana poigai (Fig.46-48). The values of nitrate range between

0.11mg/l to 0.59mg/l in Kanhala pond, 0.08mg/l to 0.41mg/l in Pindavani pond and 0.05mg/l to 0.80mg/l in Malhara pond (Harney *et al.*, 2013). The interrelationships noticed among various parameters seemed to indicate the cultural eutrophication as the major reason for the changes in characteristics of the physical, chemical and nutrient characteristics of water in these ponds. Besides the influence of seasonal changes also seem to accelerate this eutrophication that get reflected in the zooplankton counts. At the same time, the altitudinal differences in the location of these ponds influence the changes in physical, chemical and nutrient parameters of these ponds by curtailing the human interferences.

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References

Adoni AD; Joshi G; Gosh, K, Chowasia. S. K, Vaishya, A. K, Yadav, M and Verma, H, G 1985 Work book on Limnology. Prathibha Publishers, Sagar, India

Amshadevi V; Baskaran S and Sureshkumar R 2013 Physico-chemical parameters and zooplankton diversity of a temple pond in Virudhunagar, Tamilnadu. *Inter. J. Sci., Envir. & Tech.* 2(2): 250-257

APHA 1995 Standard Method for the Examination of water, sewage and Industrial water, American Public Health Association. New York. pp 1193

Ayyanna Y and Narayudu Y 2013 Hydrological study of Fresh Water Pond at Kakinada Rural Village, P.Venkatapuram, E.G.Dist, Andhrapradesh. *IOSR J. Appli. Chem. (IOSR-JAC)* 3(6): 1-5

Banita DM; Tapati D and Susmita G 2013 Limnological Studies of Temple Ponds in Cachar District, Assam, North East India. *Int. Res. J. Envi. Sci.* 2(10): 49-57

Carpenter SR; Stanley EH and Vander Zanden MJ 2011 State of the world's freshwater ecosystems: physical, chemical and biological changes. In: Annual Review of Environment and Resources. pp. 75-99

Harney NV; AA Dhamani and RJ Andrew 2013 Seasonal variations in the Physico-chemical parameters of Pindavani Pond of Central India. *Science Weekly,* 1(6): 1-8

Jemi RJ and Balasingh GSR 2011 Studies on physico chemical Characteristics of fresh water Temple ponds in Kanyakumari District (South Tamilnadu). *Int. J. Geology, Earth & Envi. Sci.* 1(1): 59-62

Joshi AS and R Bhalla 2012 Assessment of water quality of Girna River at Chanakapur area of Kalwan (M.S). *PDFARDIJ [PRINT]* 5(12): 79-85

Kodarkar MS 1992 Methodology for water analysis IAAB publication No.2, Hyderabad: 1-26

Lendhe RS and Yeragi SG 2004 Physico-chemical parameters and zooplankton diversity of Phirange-Kharbav Lake, district Thane, Maharastra. *J. Aqua. Biol.* 19(1): 49-52

Mackereth FJ; Haron J and Talling JF 1978 Water analysis. *Freshwater Biol. Assoc. Sci. Publ.* No. 36

Moyle JB 1946 Some indices of lake productivity trends. *Ameri. Fish. Soc.* 76: 322-334

Muley DV and P T Gaikwad 1999 Limnological studies of Shiroli reservoir - A case study. Freshwater ecosystem of India. Ed. K. Vijaykumar, Daya Publi. House, Delhi. pp 109-132

Munawar M 1970 Limnological studies on freshwater ponds of Hyderabad, India. II. The biocenose distribution of unicellular and colonial phytoplankton in polluted and unpolluted environments. *Hydrobiol*. 36(1): 105-128

Narayana J and Puttaiah ET and Basavaraja D 2008 Water quality characteristics of Anjanapuram reservoir near Shikaripur, District Shimoga, Karnataka. *J. Aqua. Biol.* 23(1): 59-63

Padate GS; Ekhande AP and Patil JV 2014 Seasonal variations in density and species richness of Microcrustacea of high altitude Lotus Lake, Toranmal Maharashtra. *Weekly Sci. Res. J.* 1(30): 1-9

Rameshbabu K and Selvanayagam M 2013 Seasonal variations in physico-chemical parameters and heavy metals concentration in water and sediment of Kolavoi Lake, Chengalpet, India. *Int. J. Chem. Tech. Res.* 5(1): 532-549

Sharma KK; Devi A; Sharma A and Neha A 2013 Zooplankton Diversity and Physico-Chemical Conditions of a Temple Pond in Birpur (J & K, India). *Int. Res. J. Environment Sci.* 2(5): 25-30

Strickland JP and Parsons TR 1972 A practical book of sea water analysis. Ottawa. *Bull. Fish Res. Cananda.* pp 167

Thirugnanamoorthy K and Selvaraju M 2009 Phytoplankton diversity in relation to Physico-chemical parameters of Gnanaprakasam Temple Pond of Chidambaram in Tamilnadu, India, *Recent Res. in Sci. & Tech.* 27*:* 449-451

Tidame SK and Shinde SS 2012 Report on correlation of zooplankton with physico- chemical factors from freshwater temple pond. *J. Experi. Sci.* 3(7): 13-16

Uchchariya DK and Saksena DN 2012 Study of Nutrients and Trophic Status of Tighra Reservoir, Gwalior (Madhya Pradesh), India. *J. Nat. Sci. Res.* 2(8): 97-110

Wilcox and Hatcher 1950 Phenol-disulphonic method. In: Methodology for water analysis. M.S.Kodarkar IAAB publication No.2. pp19

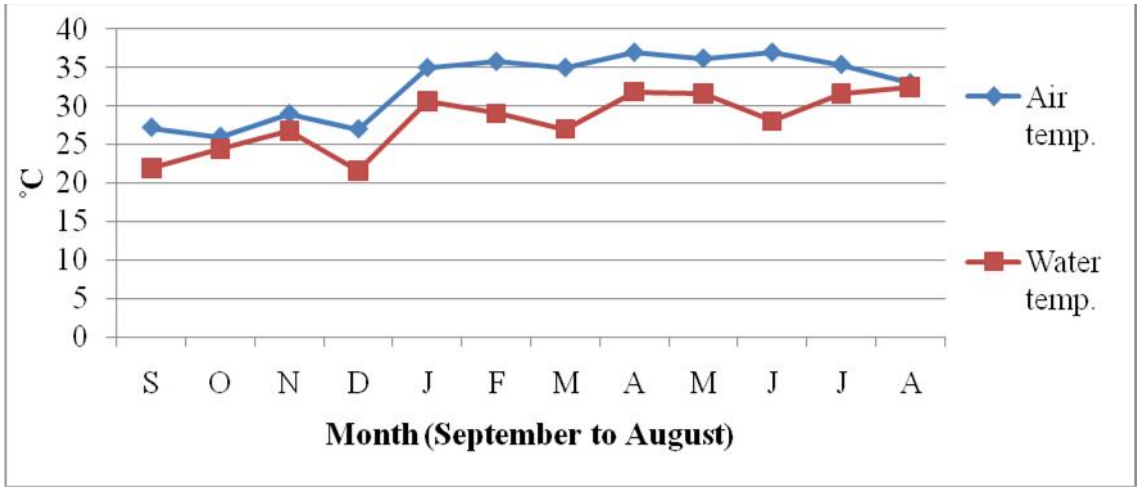

Fig.1. Monthly variation of air and surface water temperature in Kasi theertham (2009-10).

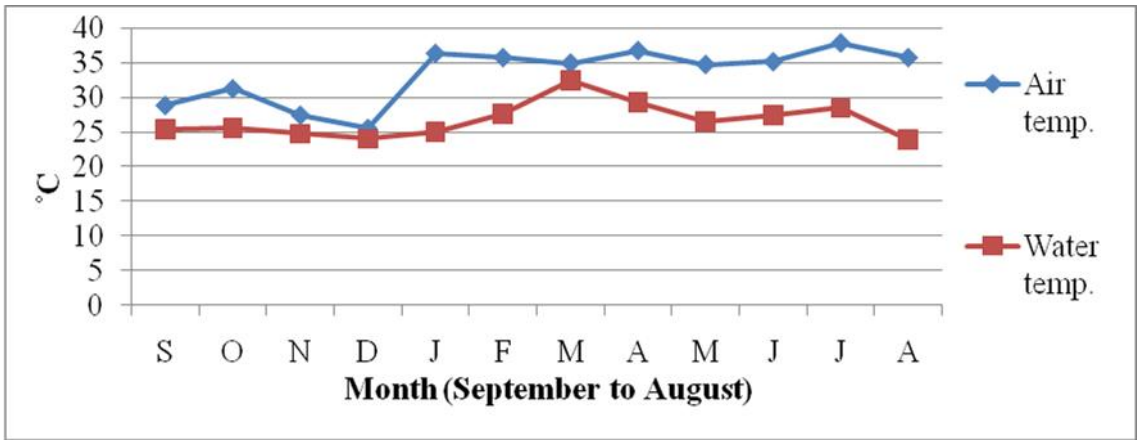

Fig.2. Monthly variation of air and surface water temperature in Kasi theertham (2010-11).

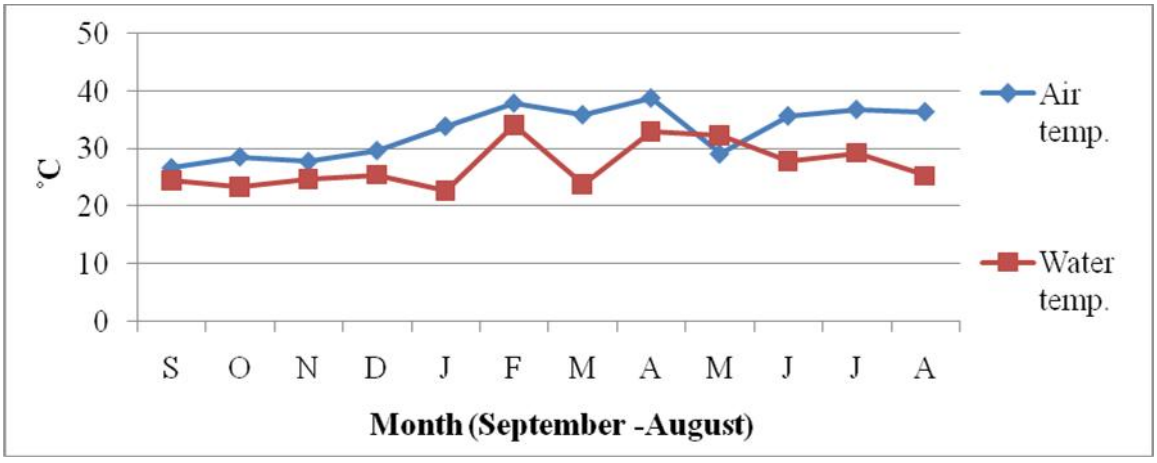

Fig.3. Monthly variation of air and surface water temperature in Kasi theertham (2011-12).

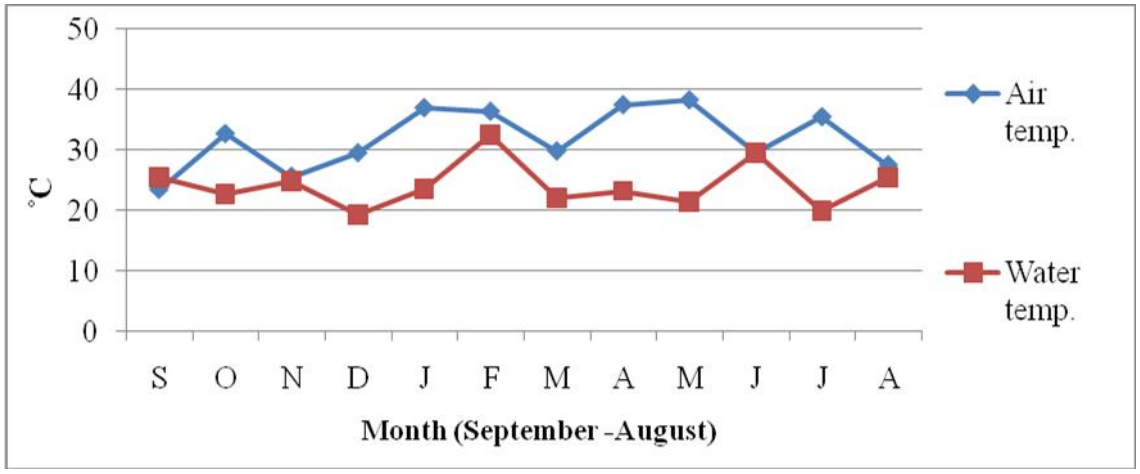

Fig.4. Monthly variation of air and surface water temperature in Lakshmi theertham (2009-10).

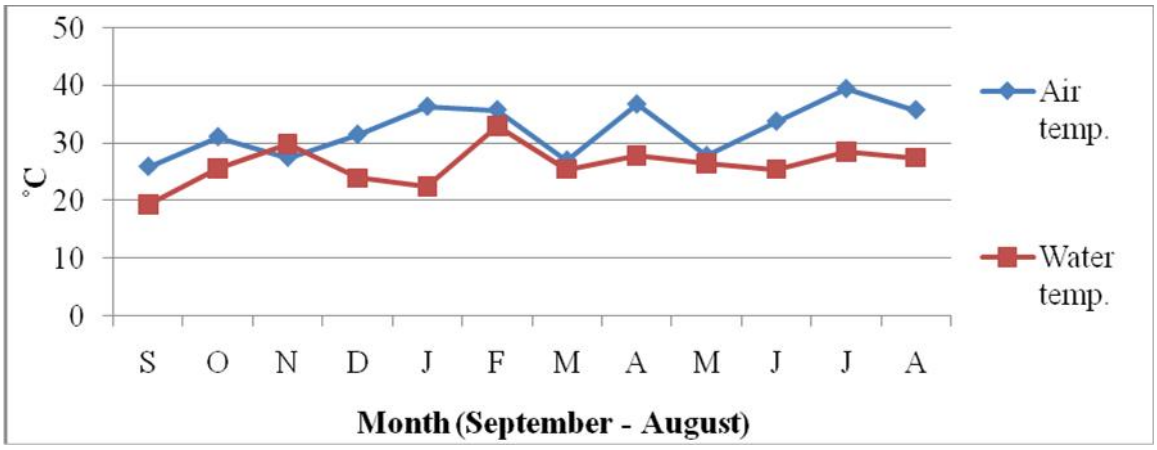

Fig.5.Monthly variation of air and surface water temperature in Lakshmi theertham (2010-11).

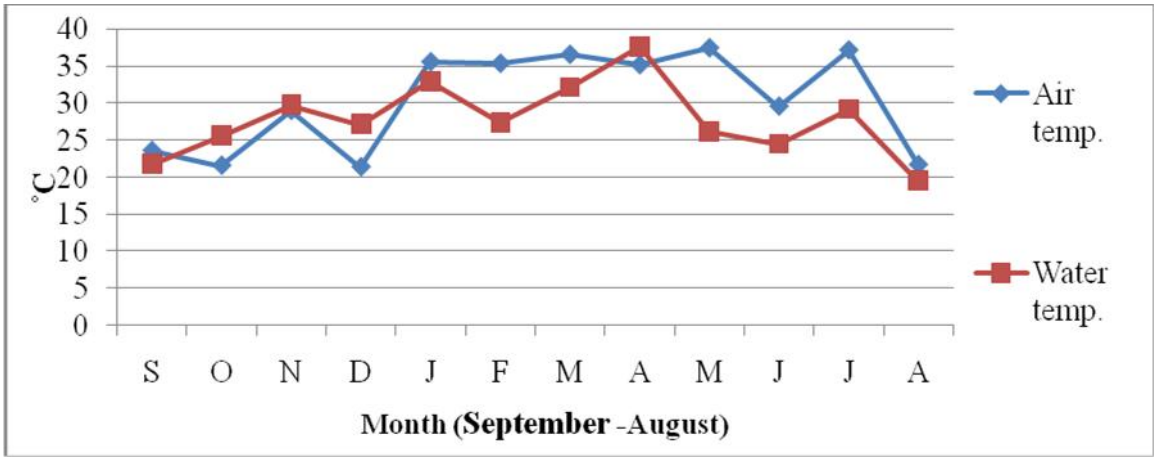

Fig.6. Monthly variation of air and surface water temperature in Lakshmi theertham (2011-12).

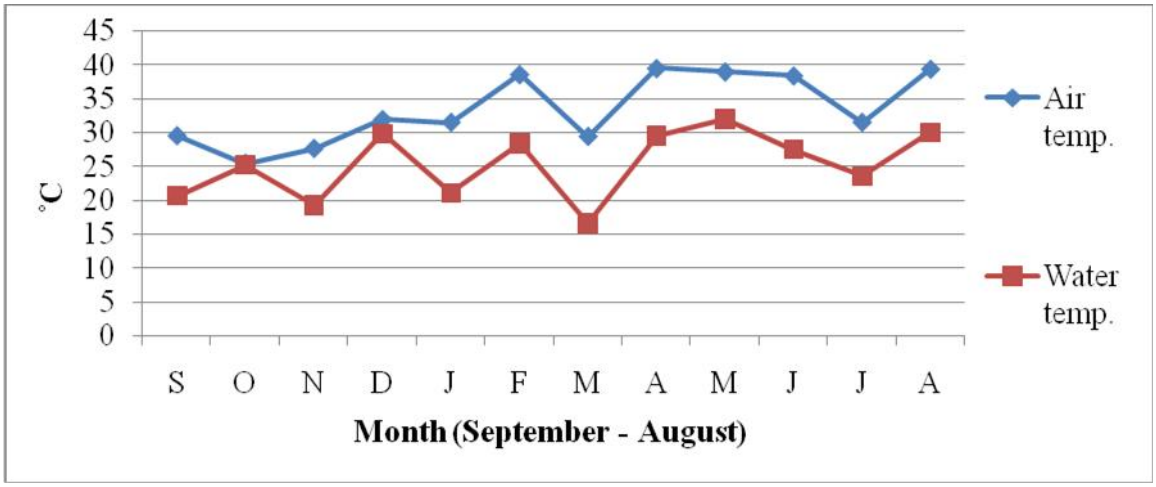

Fig.7. Monthly variation of air and water temperature in Saravana poigai (2009-10).

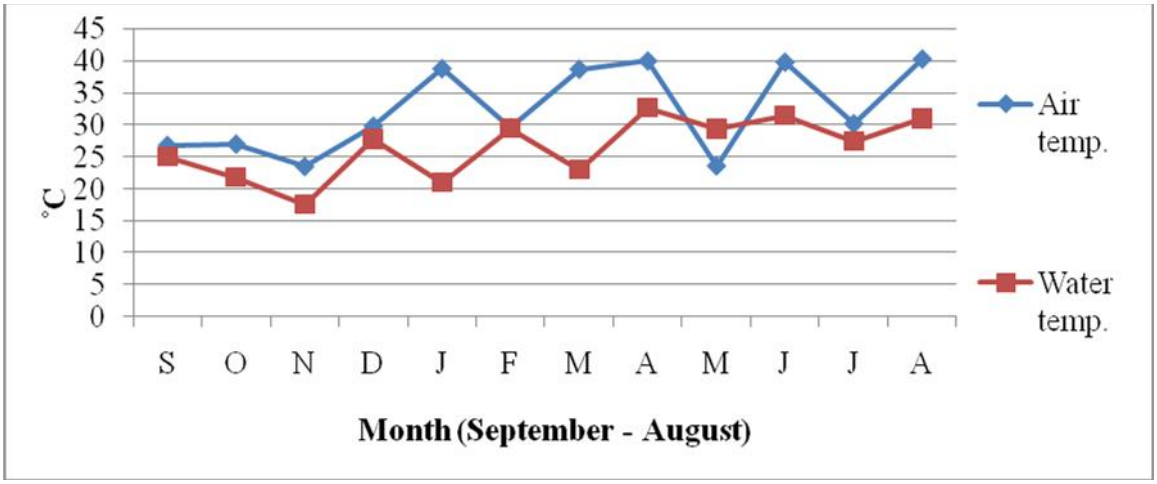

Fig.8. Monthly variation of air and water temperature in Saravana poigai (2010-11).

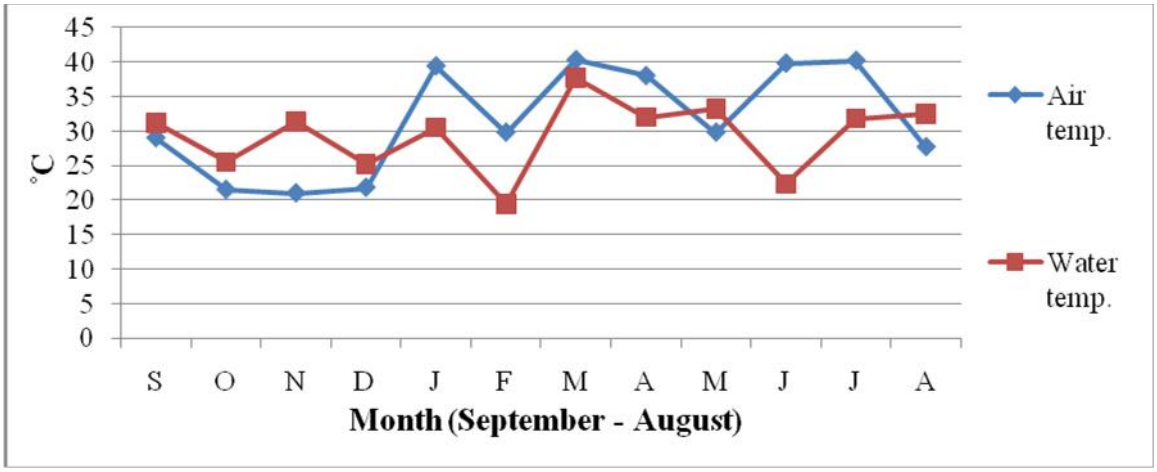

Fig.9. Monthly variation of air and water temperature in Saravana poigai (2011-12).

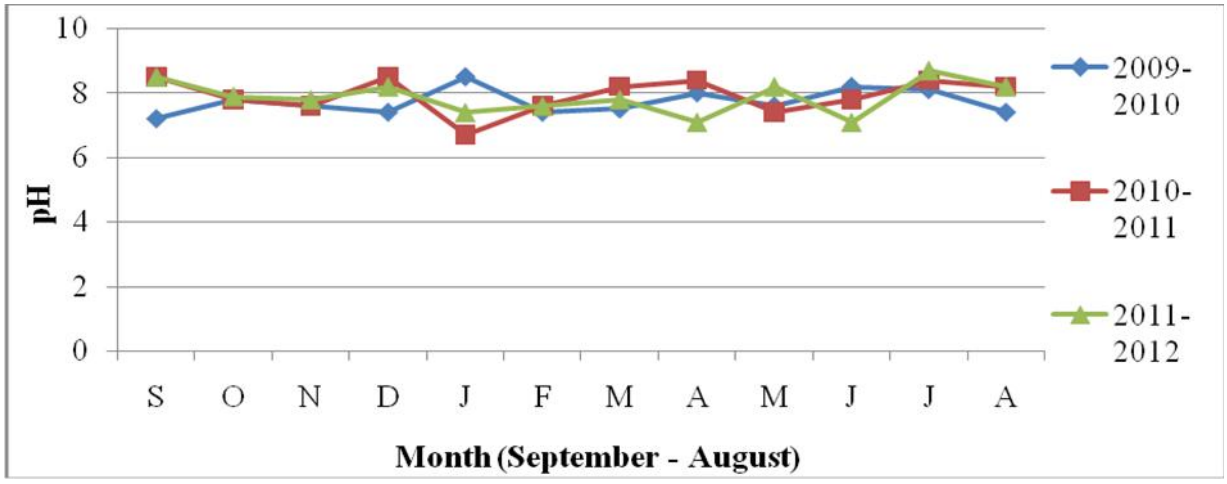

Fig.10. Monthly variation of pH in Kasi theertham observed during (2009-2012).

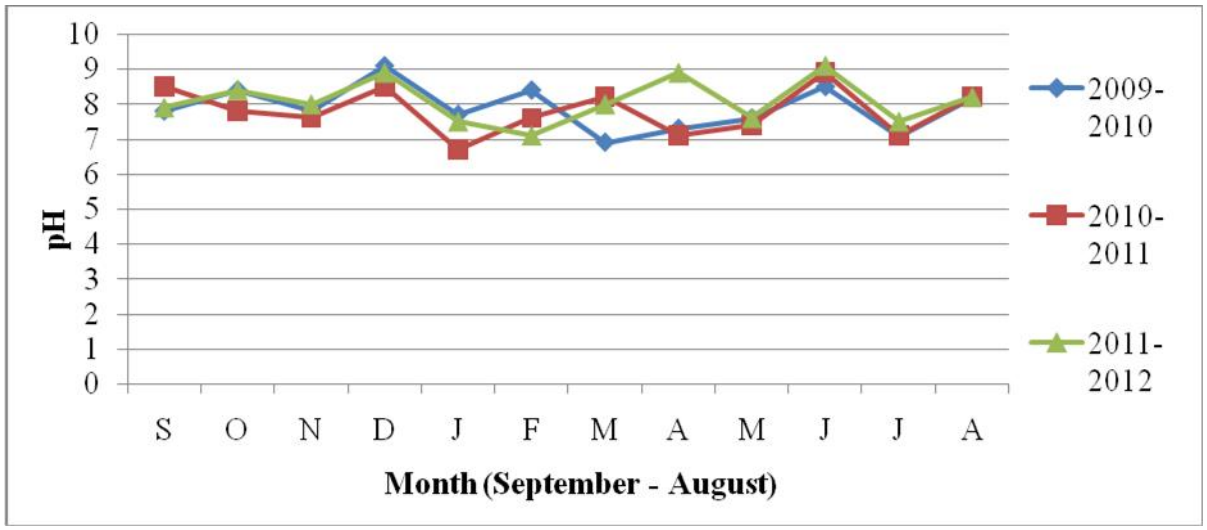

Fig.11. Monthly variation of pH in Lakshmi theertham observed during (2009-2012).

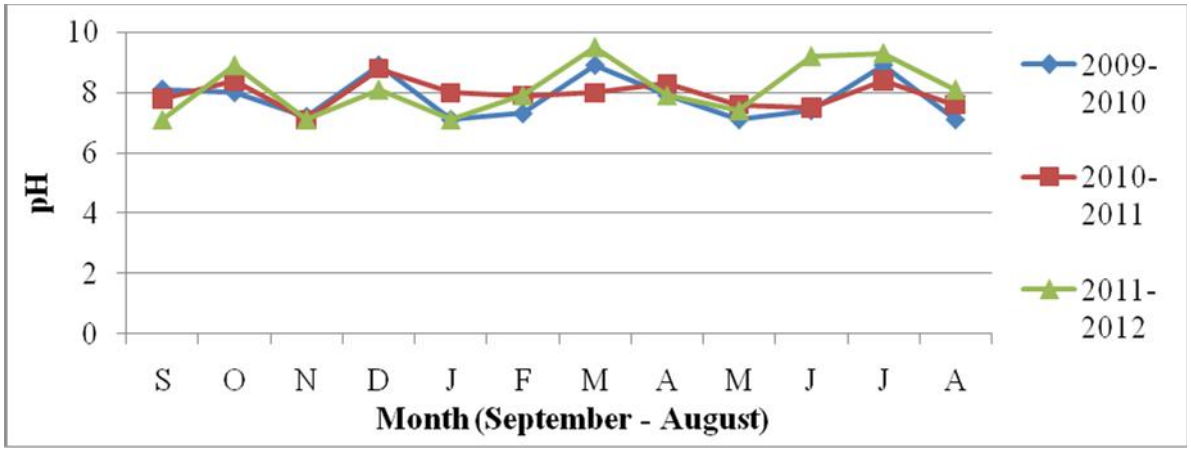

Fig.12. Monthly variation of pH in Saravana poigai observed during (2009-2012).

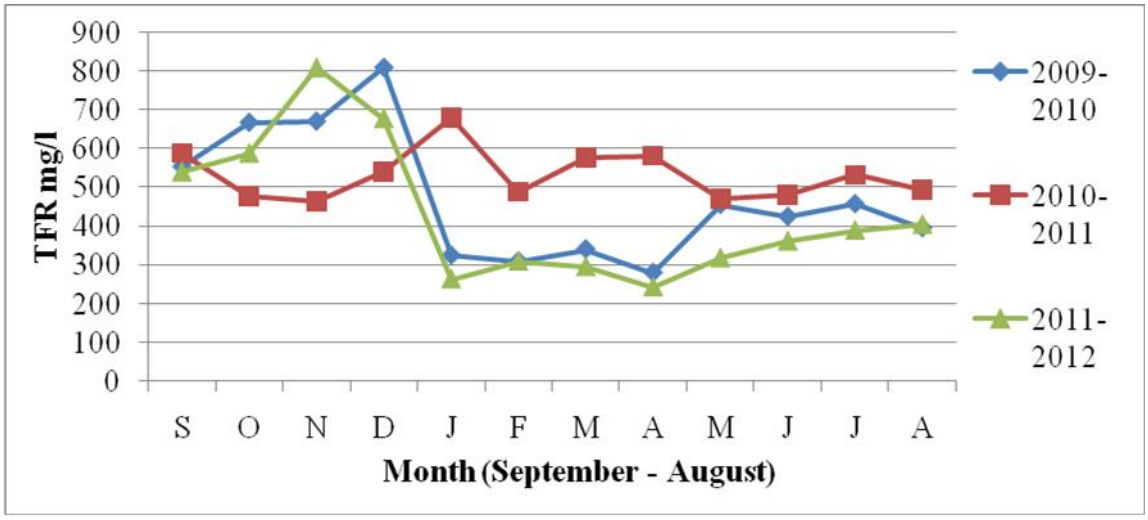

Fig.13. Monthly variation of TFR in Kasi theertham observed during (2009-2012).

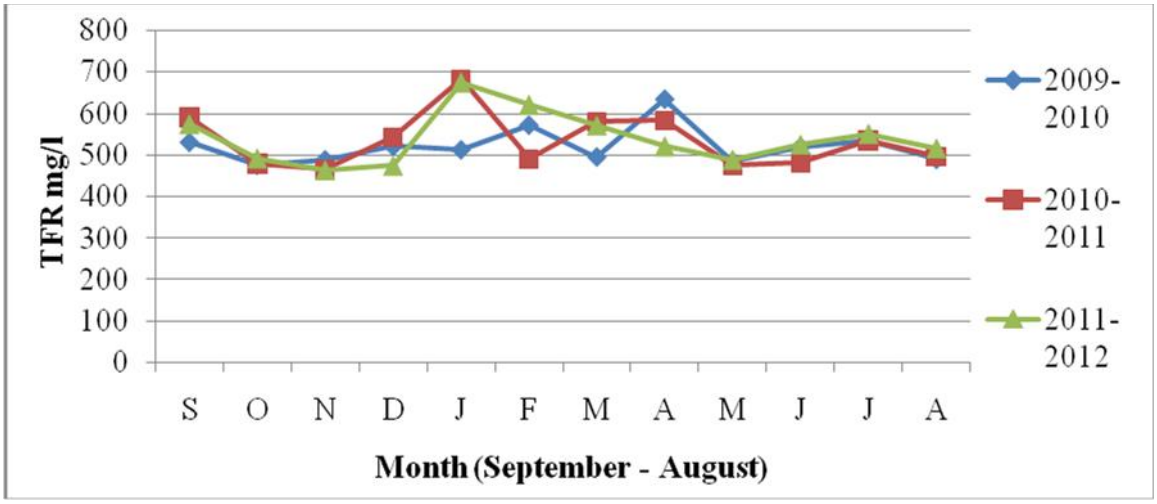

Fig.14.Monthly variation of TFR in Lakshmi theertham observed during (2009-2012).

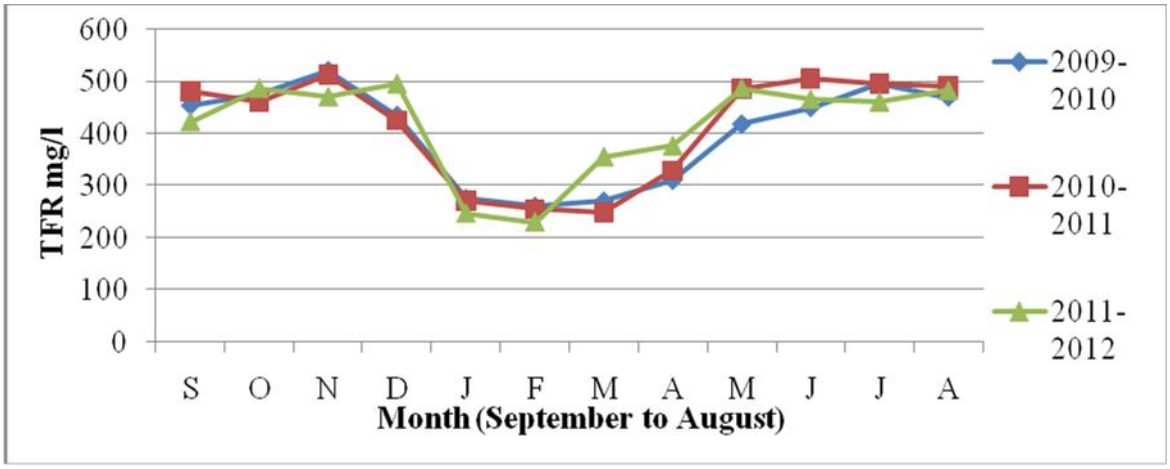

Fig.15. Monthly variation of TFR in Saravana poigai observed during (2009-2012).

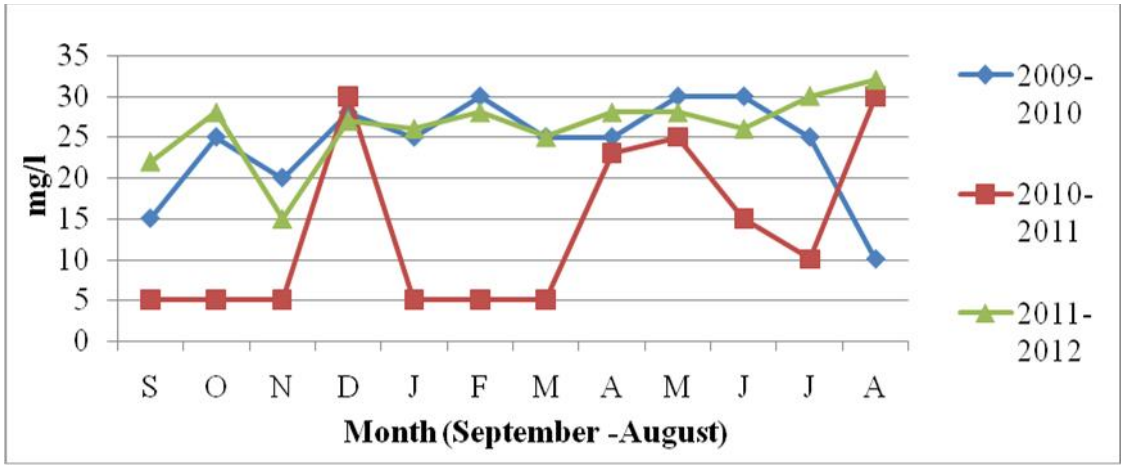

Fig.16. Monthly variation of alkalinity in Kasi theertham observed during (2009-2012).

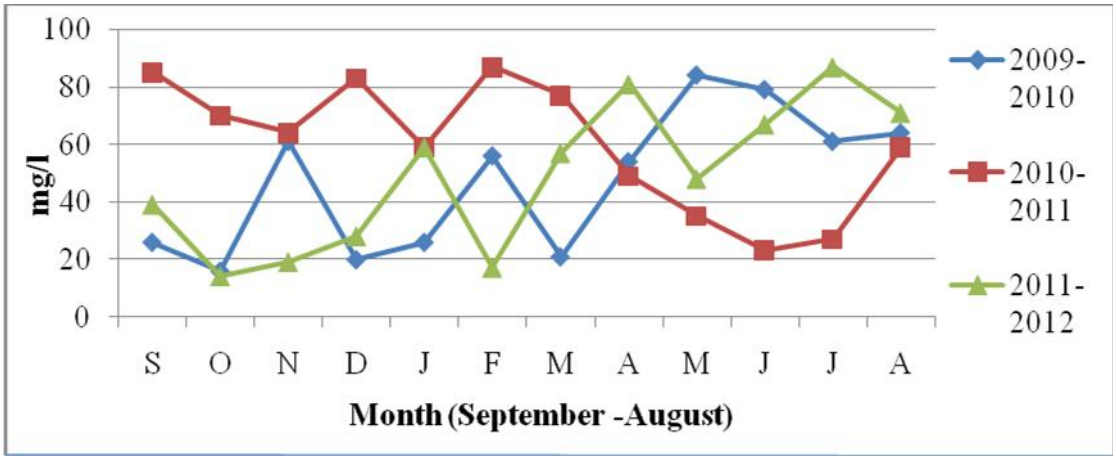

Fig.17. Monthly variation of alkalinity in Lakshmi theertham observed during (2009-2012).

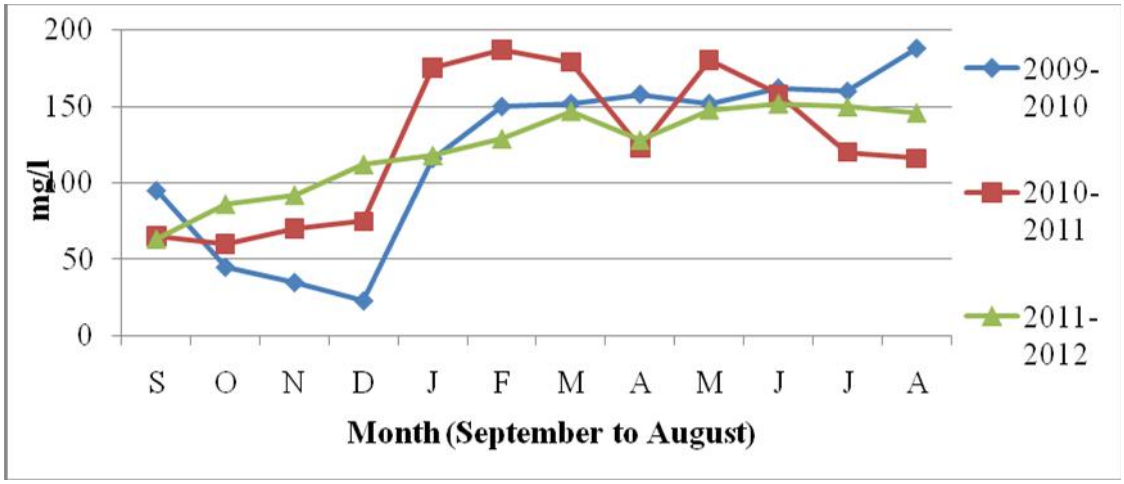

Fig.18. Monthly variation of alkalinity in Saravana poigai observed during (2009-2012).

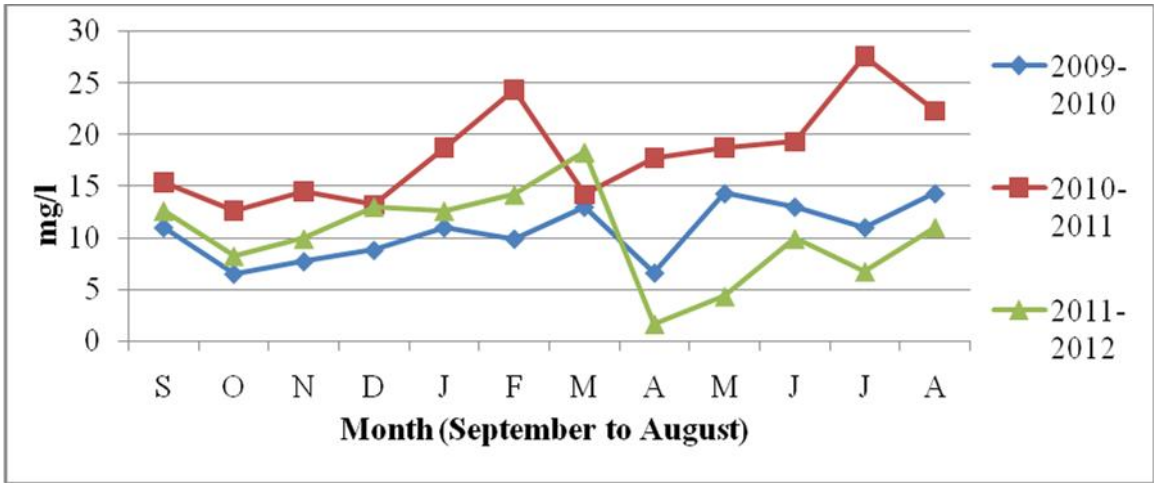

Fig.19.Monthly variation of free CO_2 in Kasi theertham observed during (2009-2012).

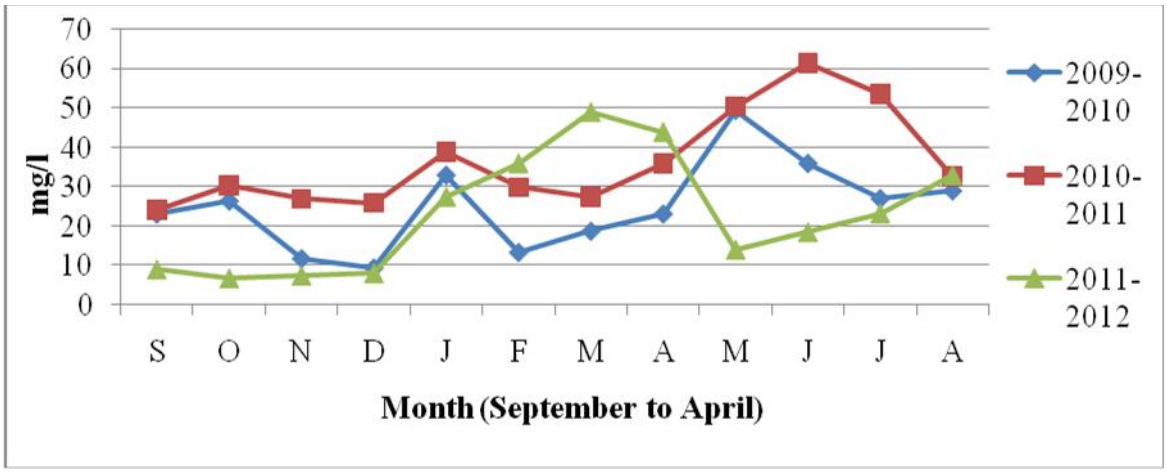

Fig.20. Monthly variation of free CO_2 in Lakshmi theertham observed during (2009-2012).

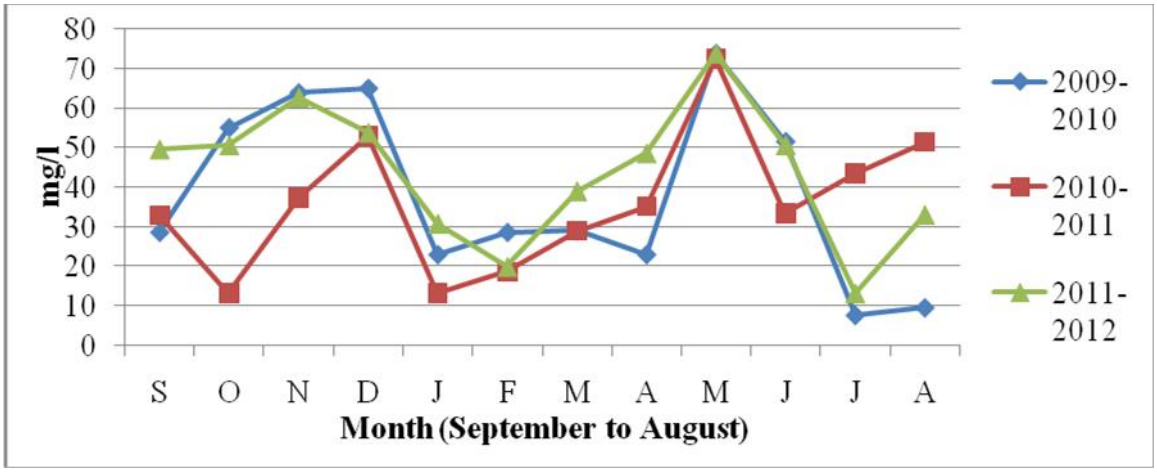

Fig.21. Monthly variation of free CO_2 in Saravana poigai observed during (2009-2012).

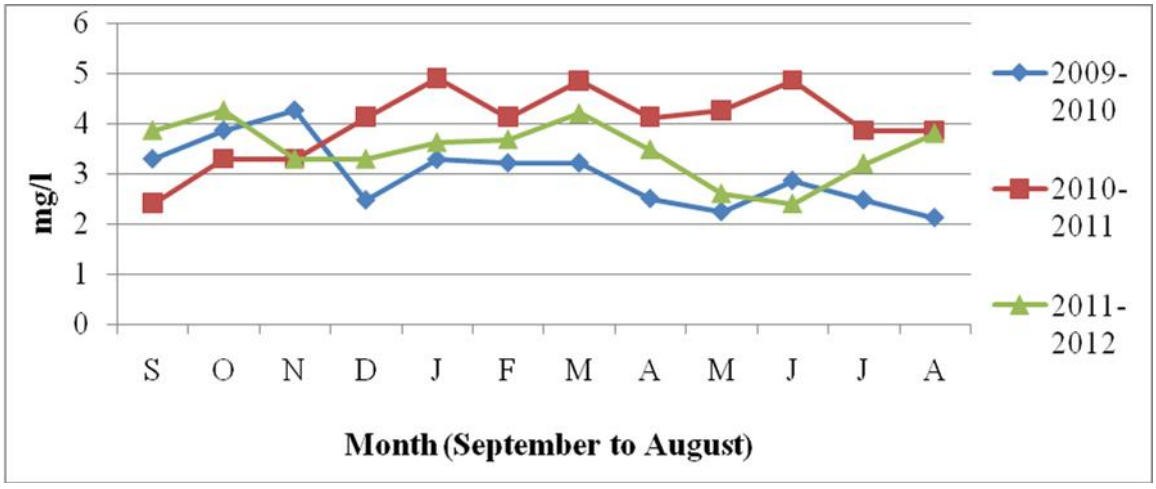

Fig.22. Monthly variation of dissolved O_2 in Kasi theertham observed during (2009-2012).

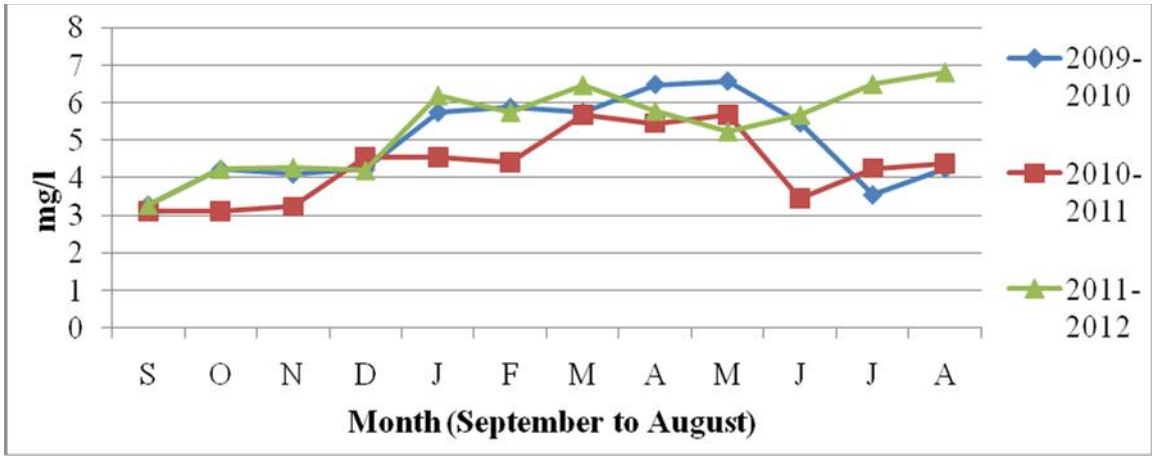

Fig.23. Monthly variation of dissolved O_2 in Lakshmi theertham observed during (2009-2012).

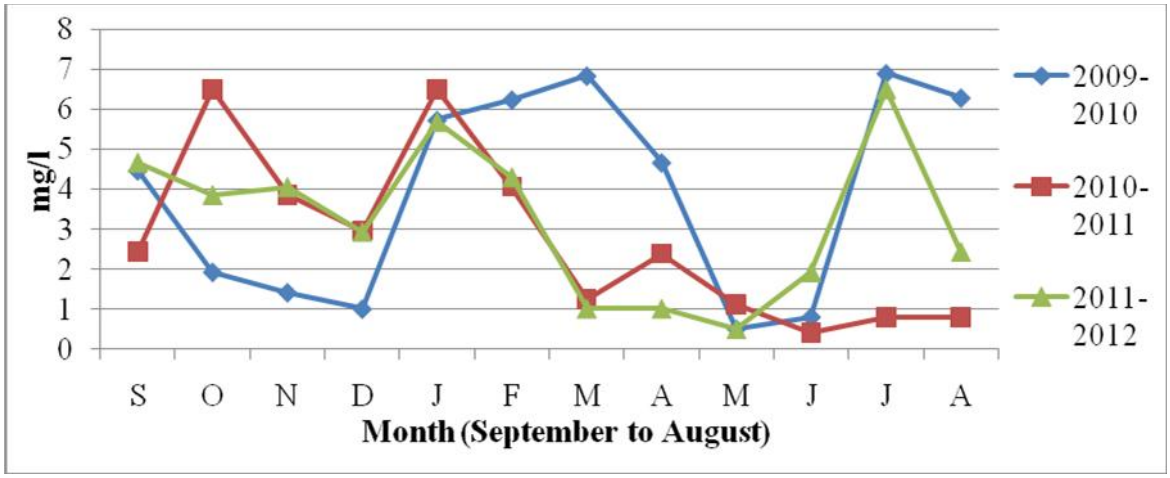

Fig.24. Monthly variation of dissolved O_2 in Saravana poigai observed during (2009-2012).

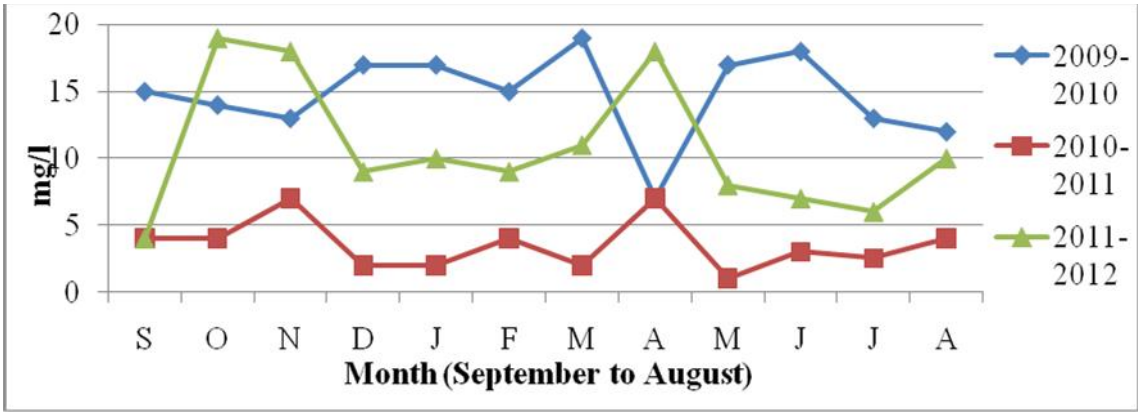

Fig.25. Monthly variation of salinity in Kasi theertham observed during (2009-2012).

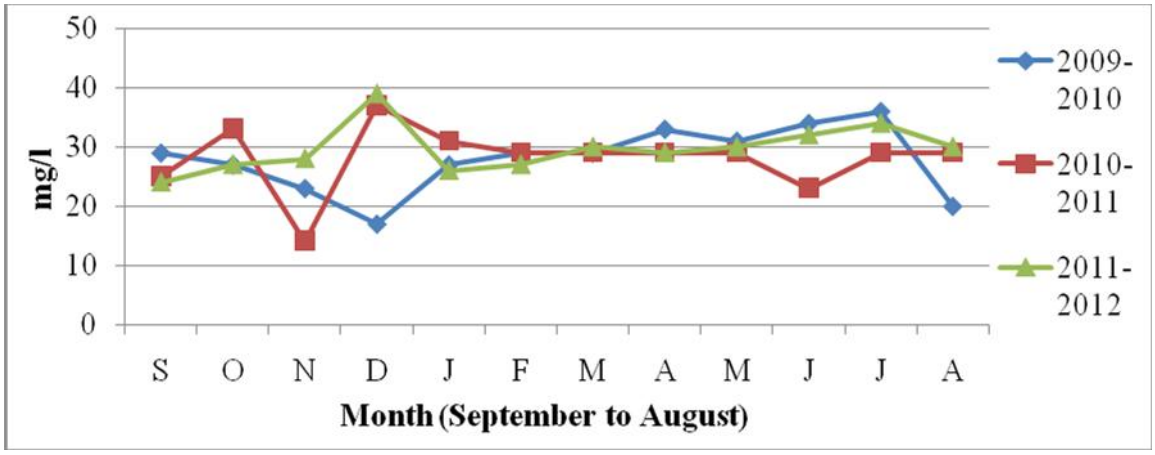

Fig.26. Monthly variation of salinity in Lakshmi theertham observed during (2009-2012).

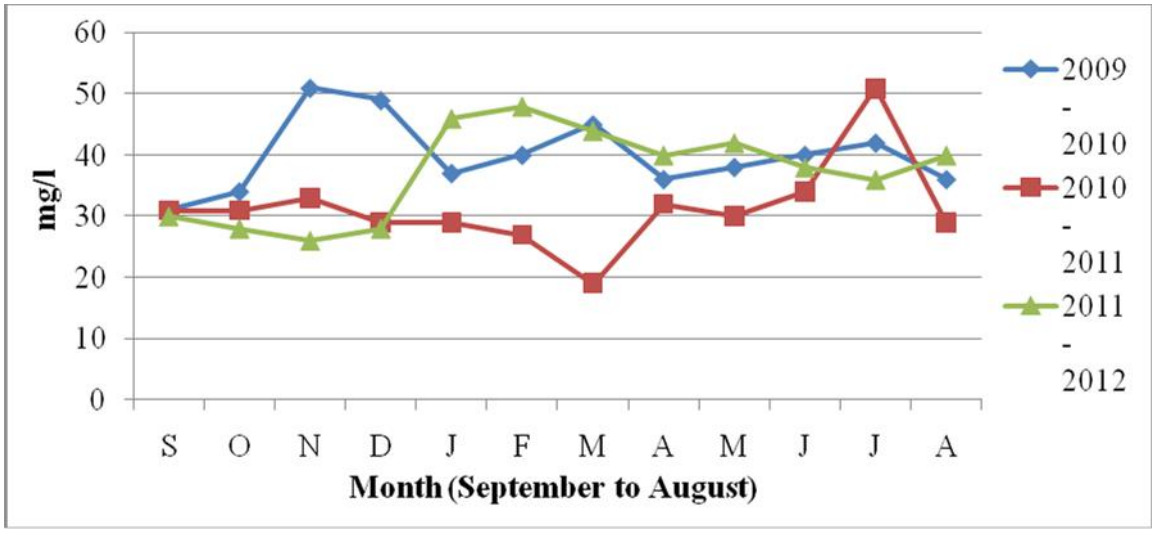

Fig.27. Monthly variation of salinity in Saravana poigai observed during (2009-2012).

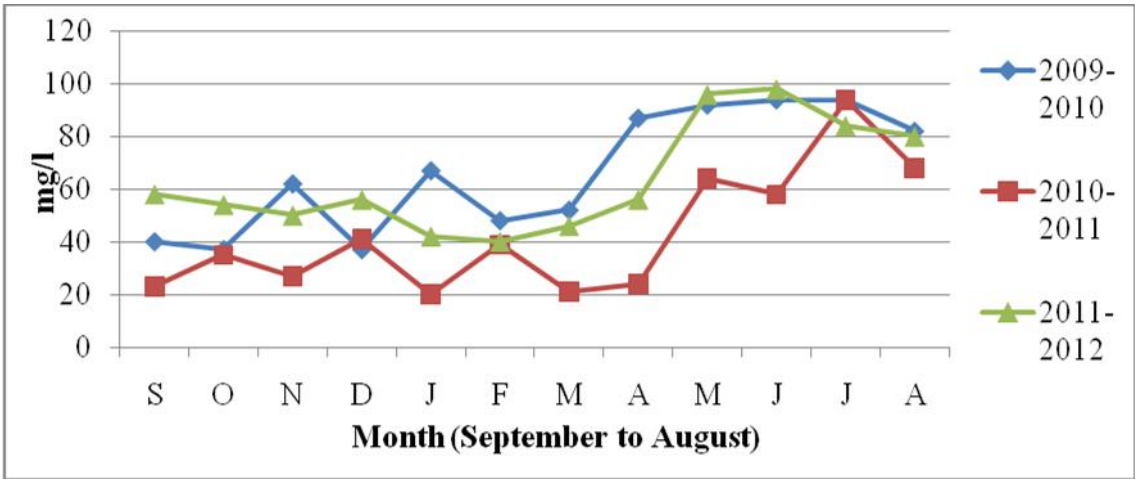

Fig.28. Monthly variation of total hardness in Kasi theertham observed during (2009-2012).

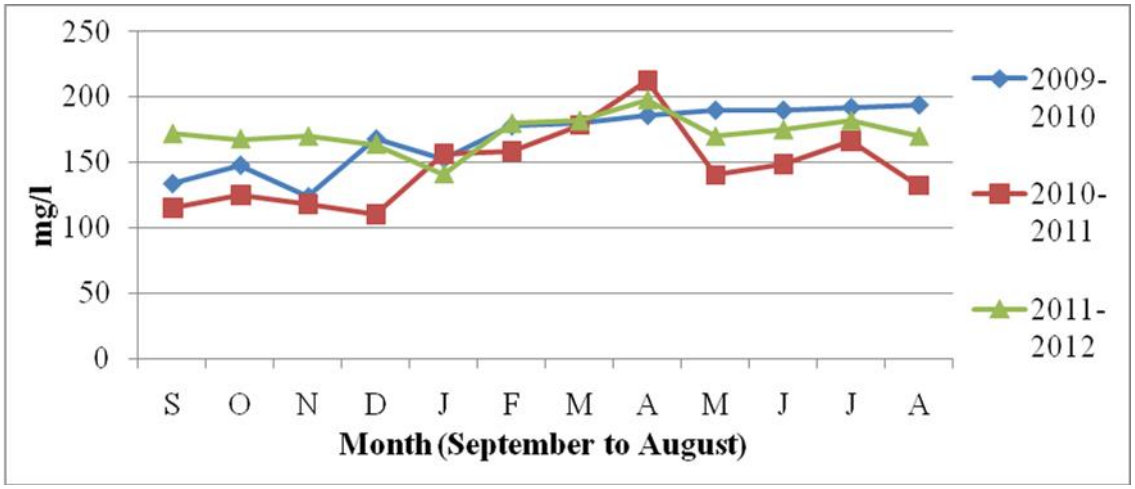

Fig.29. Monthly variation of total hardness in Lakshmi theertham observed during (2009-2012).

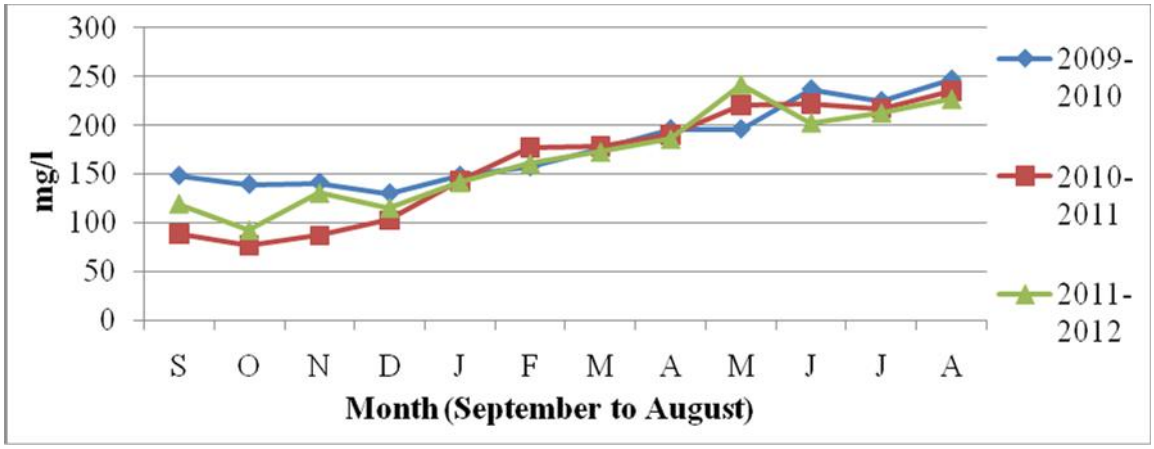

Fig.30. Monthly variation of total hardness in Saravana poigai observed during (2009-2012).

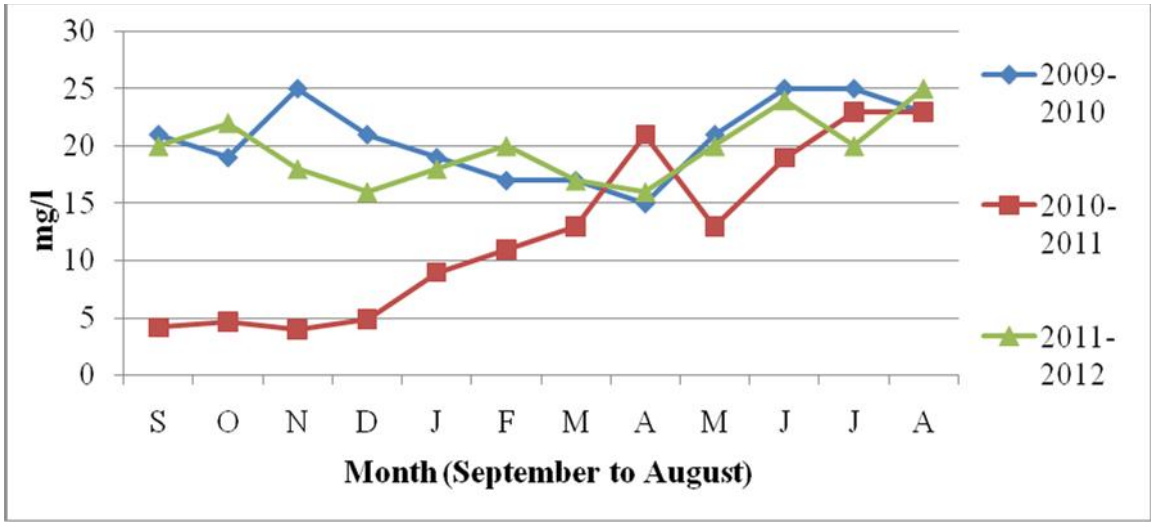

Fig.31. Monthly variation of calcium in Kasi theertham observed during (2009-2012).

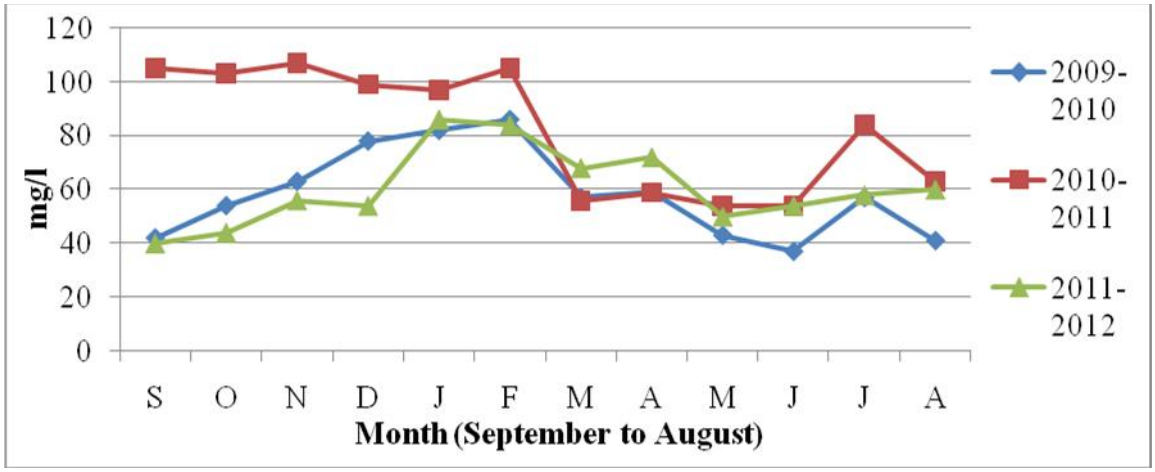

Fig.32. Monthly variation of calcium in Lakshmi theertham observed during (2009-2012).

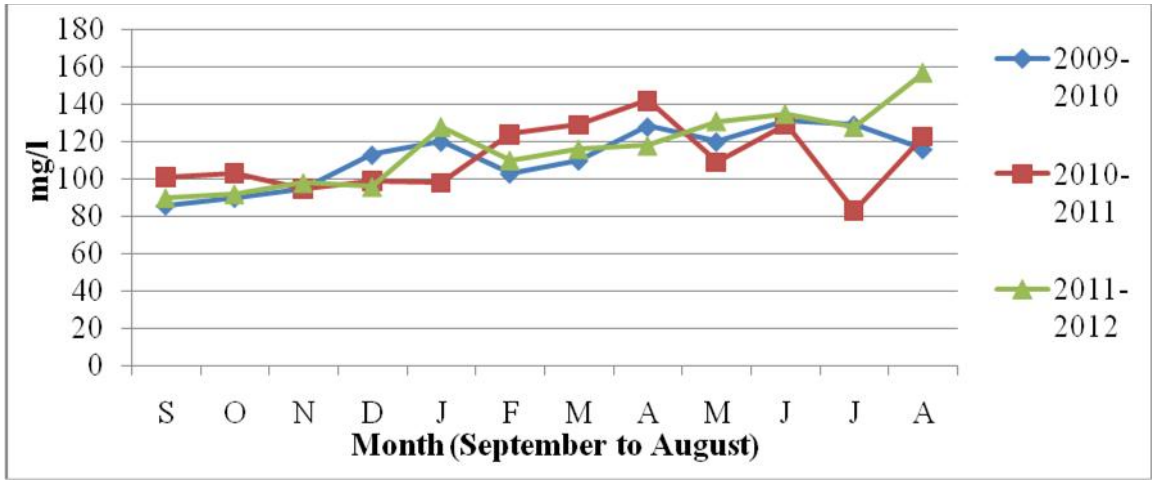

Fig.33. Monthly variation of calcium in Saravana poigai observed during (2009-2012).

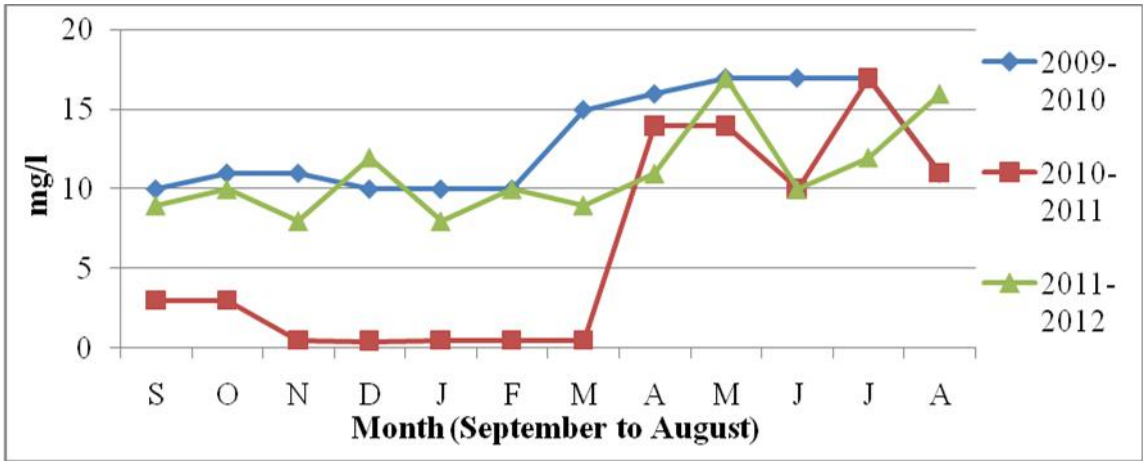

Fig.34. Monthly variation of magnesium in Kasi theertham observed during (2009-2012).

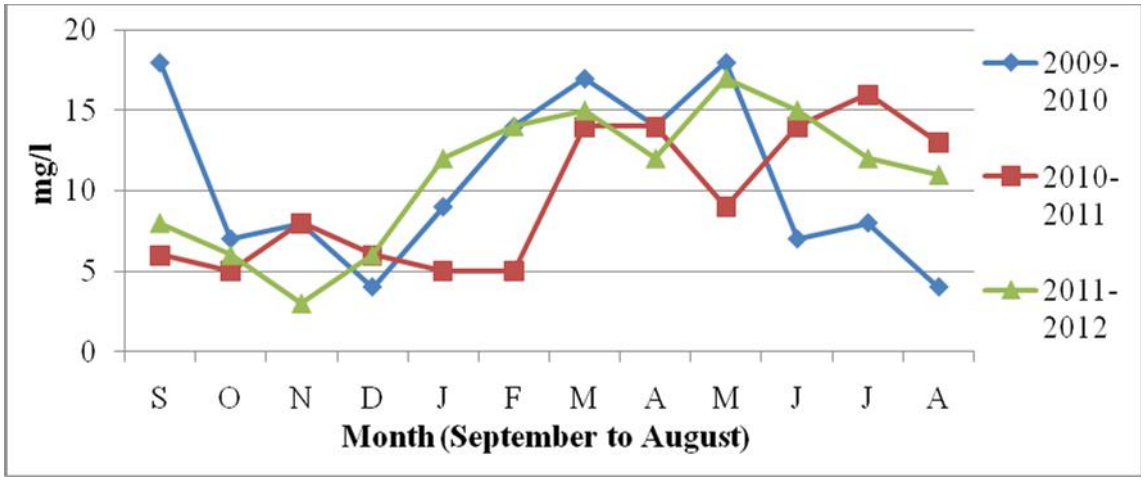

Fig.35. Monthly variation of magnesium in Saravana poigai observed during (2009-2012).

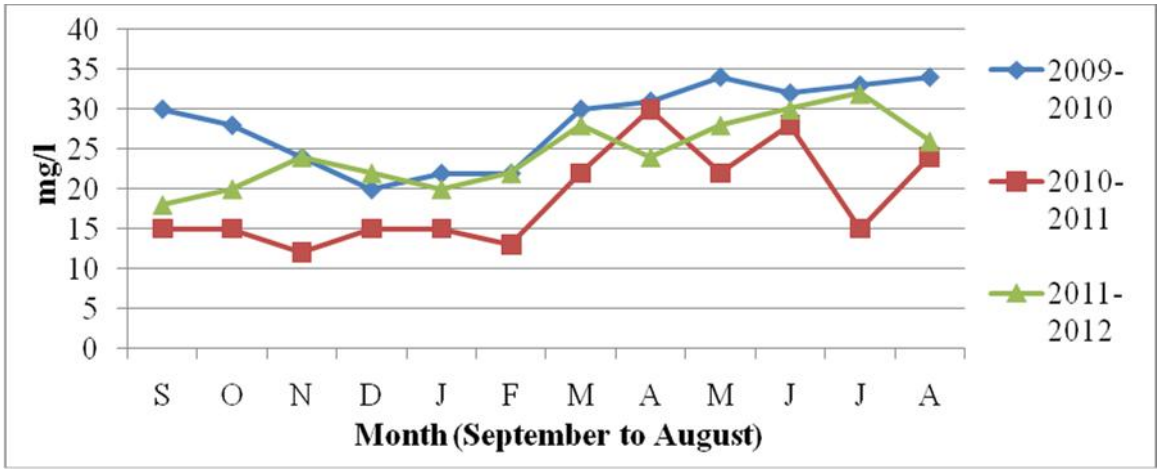

Fig.36.Monthly variation of magnesium in Lakshmi theertham observed during (2009-2012).

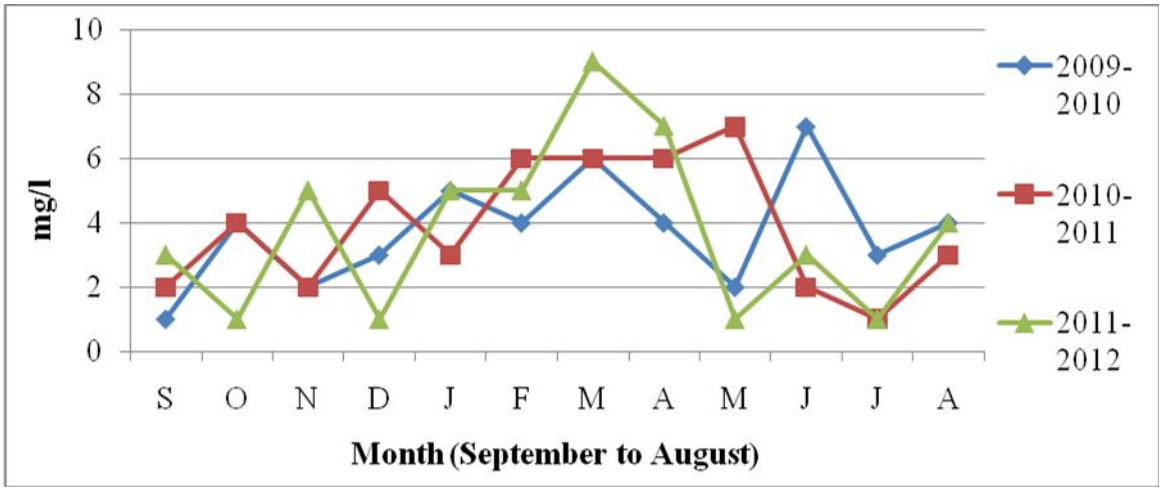

Fig.37. Monthly variation of chloride in Kasi theertham observed during (2009-2012).

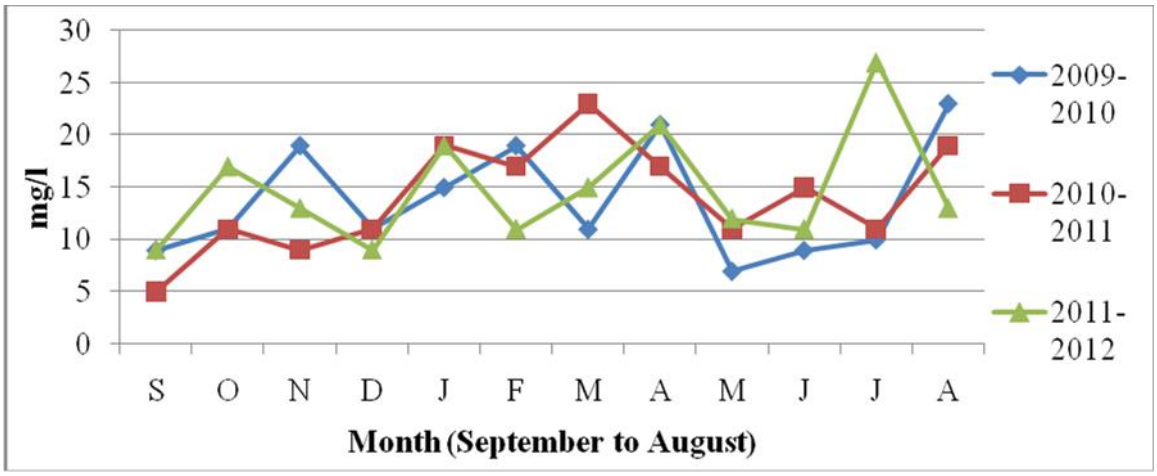

Fig.38. Monthly variation of chloride in Lakshmi theertham observed during (2009-2012).

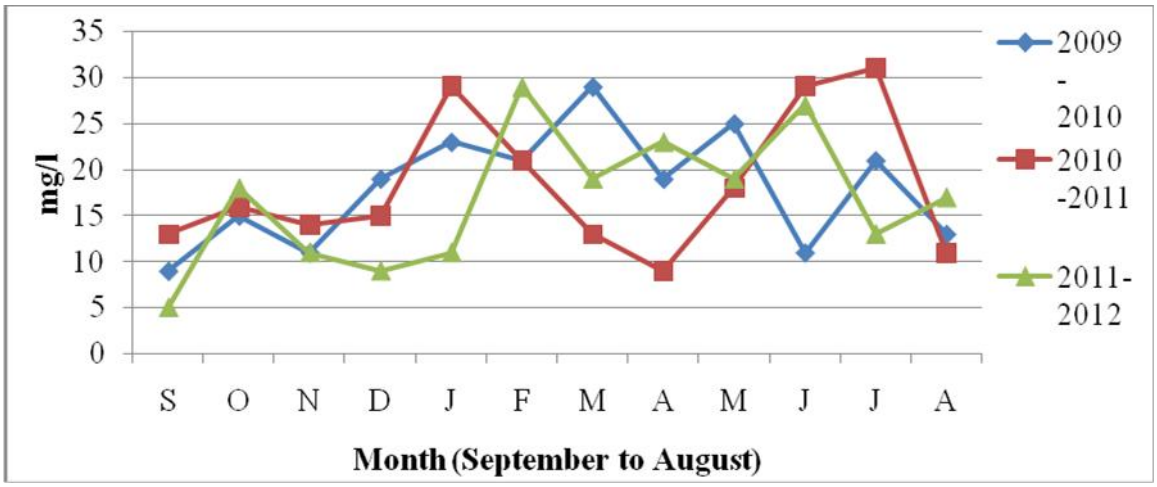

Fig.39. Monthly variation of chloride in Saravana poigai observed during (2009-2012).

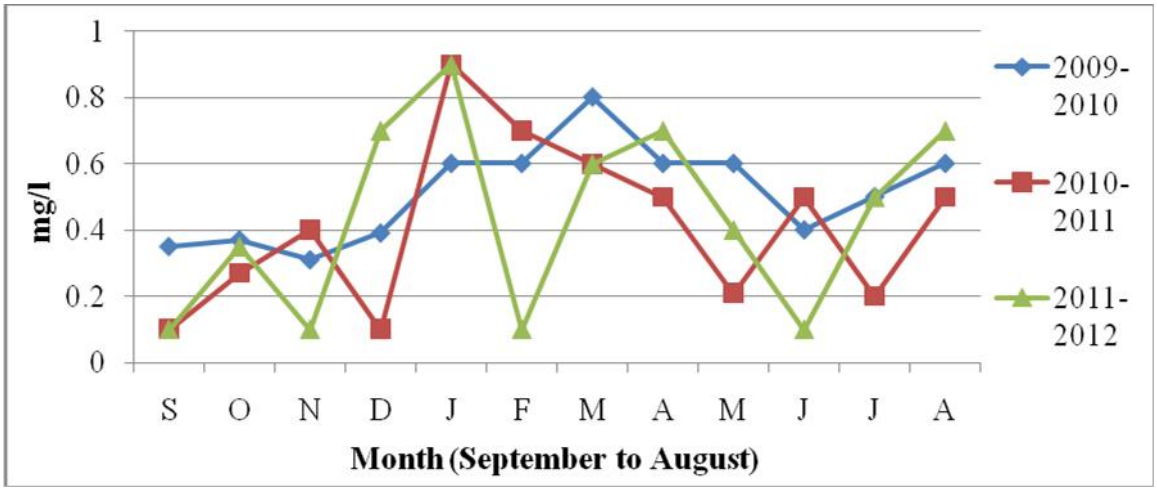

Fig.40. Monthly variation of phosphate in Kasi theertham observed during (2009-2012).

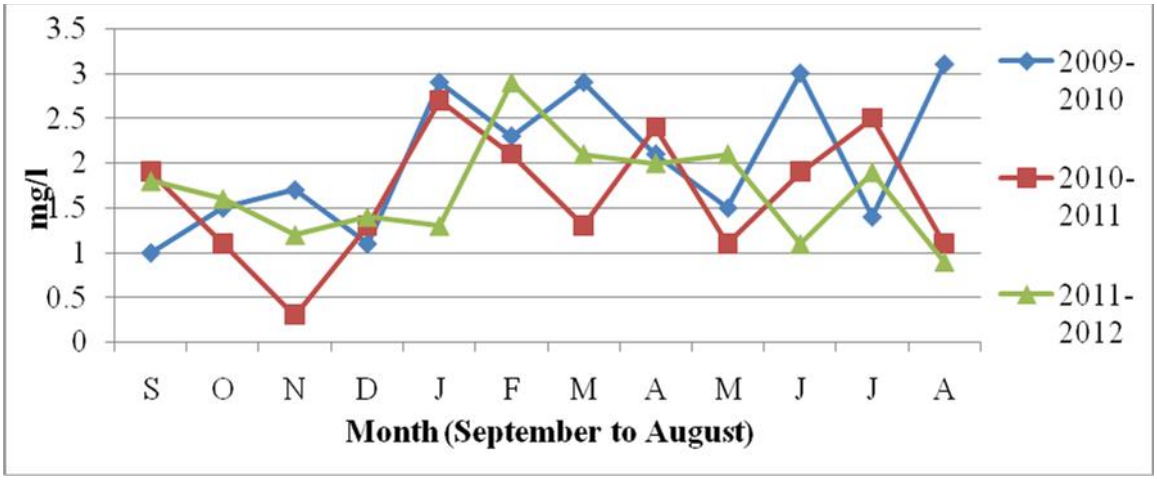

Fig.41. Monthly variation of phosphate in Lakshmi theertham observed during (2009-2012).

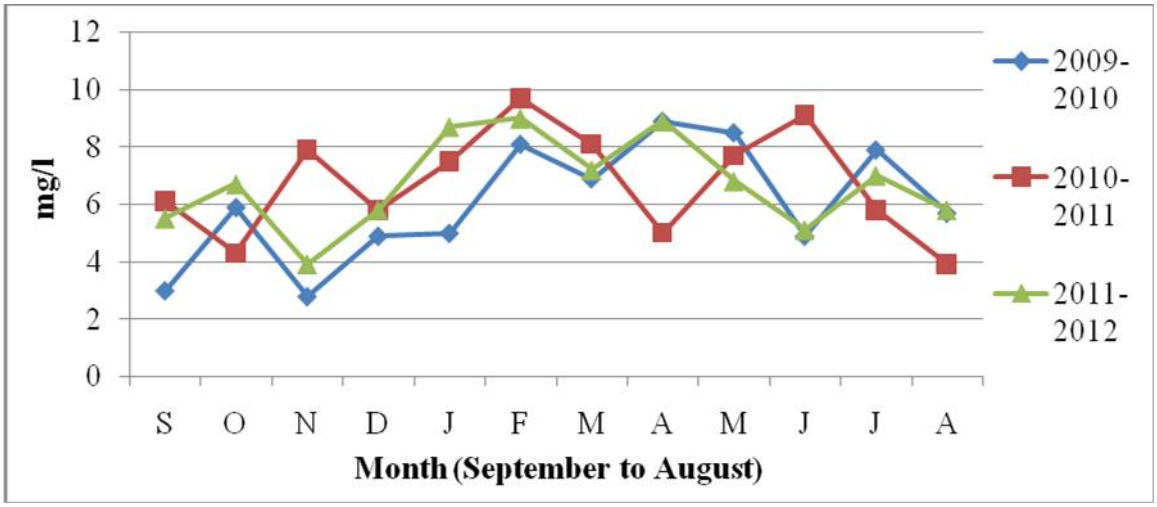

Fig.42. Monthly variation of phosphate in Saravana poigai observed during (2009-2012).

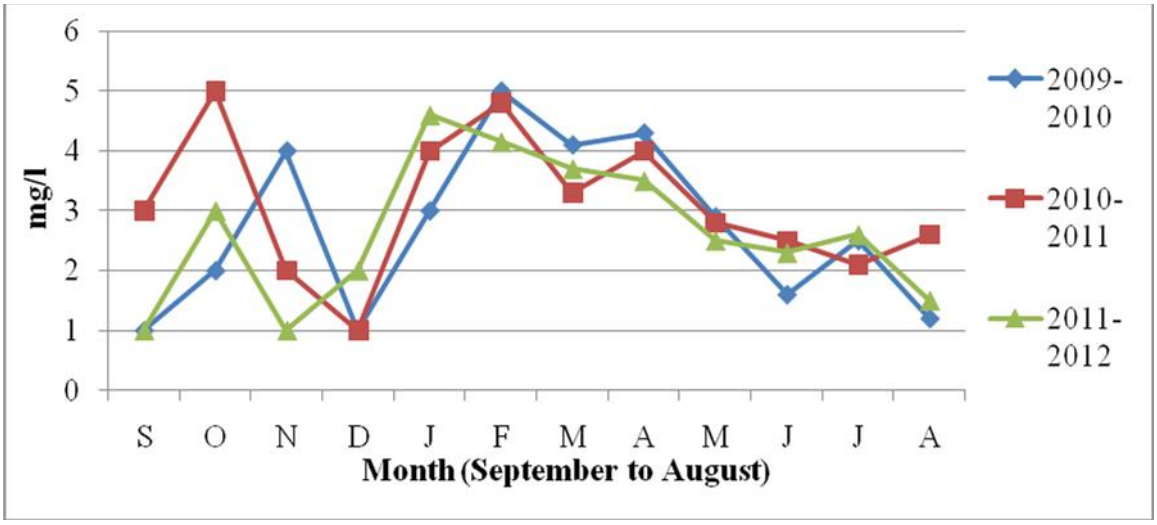

Fig.43. Monthly variation of sulphate in Kasi theertham observed during (2009-2012).

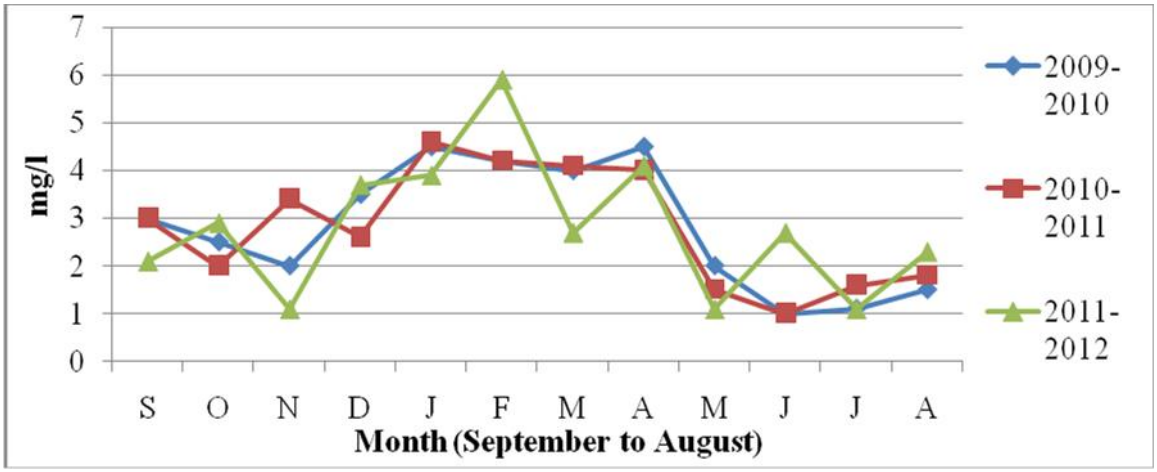

Fig.44. Monthly variation of sulphate in Lakshmi theertham observed during (2009-2012).

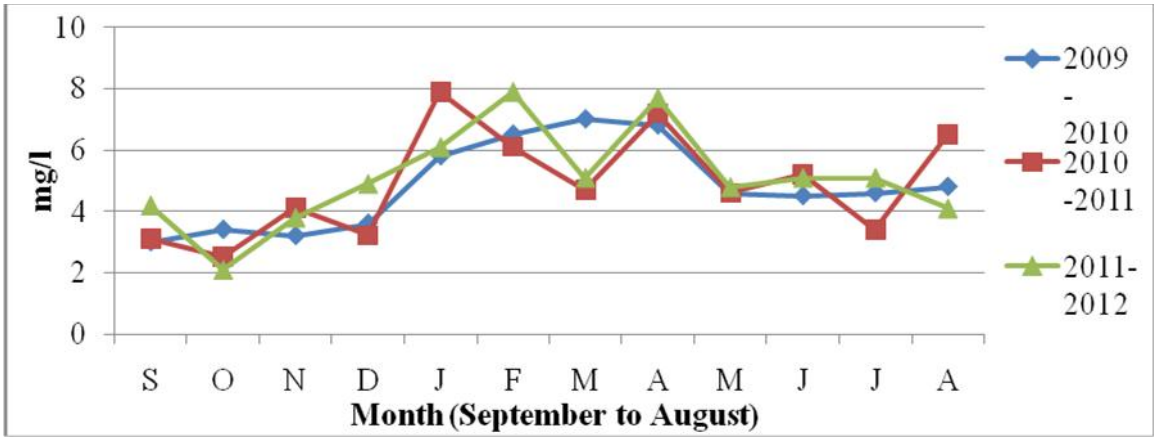

Fig.45. Monthly variation of sulphate in Saravana poigai observed during (2009-2012).

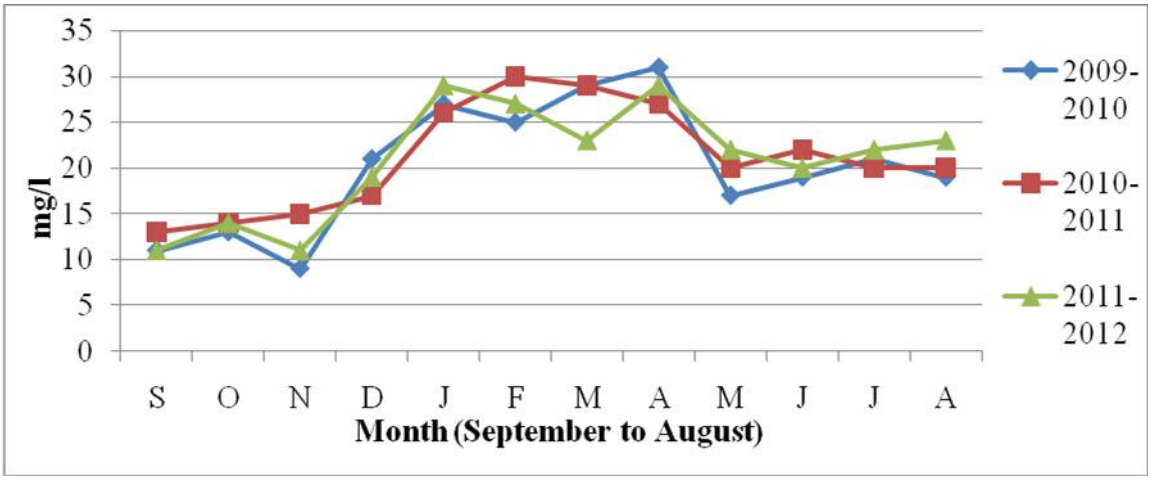

Fig.46. Monthly variation of nitrate in Kasi theertham observed during (2009-2012).

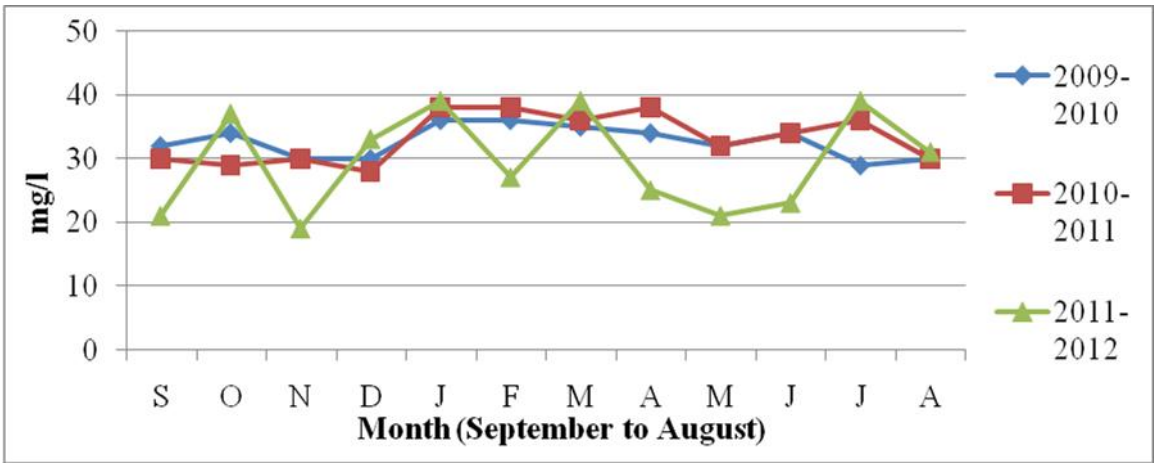

Fig.47. Monthly variation of nitrate in Lakshmi theertham observed during (2009-2012).

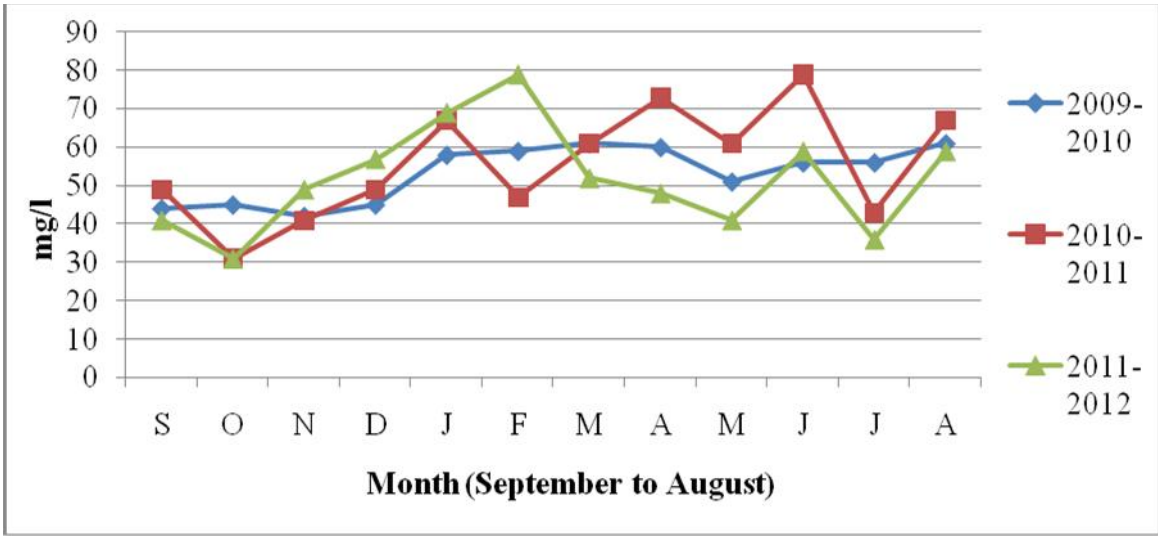

Fig.48. Monthly variation of nitrate in Saravana poigai observed during (2009-2012).