INFLUENCE OF PHYSICOCHEMICAL PARAMETERS ON ARTEMIA POPULATION IN SOLAR SALTPANS OF KANYAKUMARI DISTRICT, TAMILNADU, INDIA

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ABSTRACT--*Artemia commonly known as brine shrimp are unique inhabitants of hypersaline environments. The objective of the study is to evaluate physicochemical parameters and the population of Artemia in two selected hypersaline ecosystems of Kanyakumari district. To better understand the growth of Artemia, different physicochemical parameters including temperature, pH, salinity, dissolved oxygen and depth of water were examined from May 2018 to April 2019. The influence of physicochemical parameters on Artemia population in different seasons of saltpan ecosystem of reservoir, condenser and crystallizer pond at both stations was studied. Highest temperature was recorded (31.72°C) in crystallizer pond and pH (8.7) in condenser pond during post monsoon seasons at both stations. Highest salinity was reported (157.175ppt) from crystallizer ponds during pre monsoon at both study sites. In case of DO (5.317) and water depth (71.73) was reported maximum in reservoir pond at both stations during monsoon seasons. The different stages of Artemia populations were recorded during post monsoon season on both saltpans. Highest Artemia population (14.1) was reported from reservoir pond at both stations during post monsoon season. Parameter such as temperatures, pH, salinity, dissolved oxygen and depth of water extensively influenced the abundance of Artemia population in crystallizer pond of both study station. Artemia population was significant ($p > 0.05$) in post monsoon seasons and sampling units at station 2. The various stages of Artemia population were non-significant ($p > 0.05$) in seasons and sampling site at both study area. The abundance of Artemia population was high at station 2 from reservoir pond during post monsoon season*

Keywords-- Artemia *populations, Saltpan, physicochemical parameters, monsoon season*

I. INTRODUCTION

Extreme ecosystems refer to the habitats with adverse environmental conditions that they would exterminate or prevent growth of most forms of life on Earth (Galotti et al. 2014). Hyper saline solar salt pan habitats are considered as extreme ecosystems (Mancinelli & Rothschild 2002). Hyper saline ecosystems are defined as those containing excess salt concentrations of sea water 3.5% as total dissolved salts (Shiladitya 2006). Saltpan ecosystem is highly dynamic where the biotic horizons are subjected to susceptible physicochemical and

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environmental disturbances. Saltpans are enclosed ecosystem with unique biological niche that is characteristically exposed to a wide range of environmental stress mainly through extreme salinity changes. In the extreme physicochemical conditions of these hyper saline habitats only few plant, animal and halophilic microbial community can sustain (Amrita Biswas & Paul 2012). Saltpan ecosystem offers a number of unique ecological niches having a wide range of strange combination of environmental factors (Radhika et al. 2011). Hyper saline ecosystems are most important natural assets of considerable economic, ecological and scientific value. Hyper saline environments and biodiversity associated with such environments are affected by both human activities and natural calamity.

Artemia commonly known as brine shrimp are unique inhabitants of hyper saline environments. Biological community in these extreme environments are prokaryotes (Cho 2005), microbial eukaryotes (Park et al. 2006) and some metazoa (Elloumi et al. 2009) that tolerate hyper saline conditions. *Artemia* is used as an excellent live food source to fish and crustaceans and play a major role in the growth of aquaculture industry (Sorgeloos1980). The brine shrimp *A. franciscana* was mostly reported from the hyper saline environments like saltpan and distributed all over the world (Van Stappen 2002). *Artemia* populations can sustain in wide range of temperature (6°C-35°C) fluctuation with different ionic salt concentration. Brine shrimp in the genus of *Artemia* are the abundant macro zooplankton present in many hyper saline environments (Wurtsbaugh & Gliwicz 2001). *Artemia* play a significant role for the production of salt in salt pan ecosystem by absorbing high solar radiation from sun. The main role of *Artemia* in saltpan is the production of high quality salt has been well documented by Davis (1980). India is placed in third position of largest salt producer in the world. The major contribution around 90% of the country's total production comes from the states of Tamil Nadu, Gujarat and Rajasthan (Mani et al. 2012). India has 1, 78,848 hectare of salt pan in the coastal length stretching of 8000 km. Out of these more than 70 % of the salt works use sea water and rest use underground water ranging from 40 to 130 ppt salinity. In south India, Kanyakumari district covers about 421.5 hectare of salt work in coastal area stretching about 175 km using underground water for salt work.

Owing to the lack of studies on *Artemia* in salterns along the Cape Comorin coast, the present study was carried out to reveal the ecology, diversity, seasonal variations, frequency of occurrence and distribution of *Artemia* in relation to physico-chemical parameters in Swamythoppu and Puthalam saltpans along southern peninsular coast of India. The present study was initiated to explore the new hyper saline horizons on the assessment of *Artemia* populations with reference to correlation coefficient of physicochemical parameters. The ecological relationship in hyper saline ecosystem is providing a better understanding of the dynamics of seasonal variations on these unique biological communities.

II. MATERIALS & METHODS

2.1. Study area

The area selected for the present study includes two different Salterns Samithoppu (station -1) and puthalam (station -2) in Kanyakumari district (figure 1). Salt pan consists of separate small units used as reservoir, condenser and crystallizer ponds. Swamythoppu (station-1) study area is situated northwest around 13 km from Cape Comorin coast and southeast 12 km from Nagercoil (Capital of Kanyakumari District) with the GPS coordinates of 8° 10' 28.0200" N and 77° 25' 55.7724" E. The total area of Swamythoppu salt pan is 110 hectare which comprises 50 hectare reservoir ponds, 30 hectare condenser ponds and 30 hectare crystallizer ponds respectively. This study site is bordered by Manakkudi estuary on west side and agriculture land on remaining three sides. Puthalam (station -2) study area is situated northwest around 16 km from Cape Comorin coast and southeast 10 km from Nagercoil with the GPS coordinates of 8° 6' 21.9816'' N and 77° 28' 0.7968'' E. The total area of Puthalam saltpan is 120 hectare comprising 60 hectare reservoir ponds, 30 hectare condenser ponds and 30 hectare crystallizer ponds. It is surrounded by Manakkudi estuary on east side and agricultural land on the other three sides. Under ground water with 40ppt salinity has been used for salt work in both the study site. The Swamithoppu saltpan is 5km east to the Puthalam salt pan.

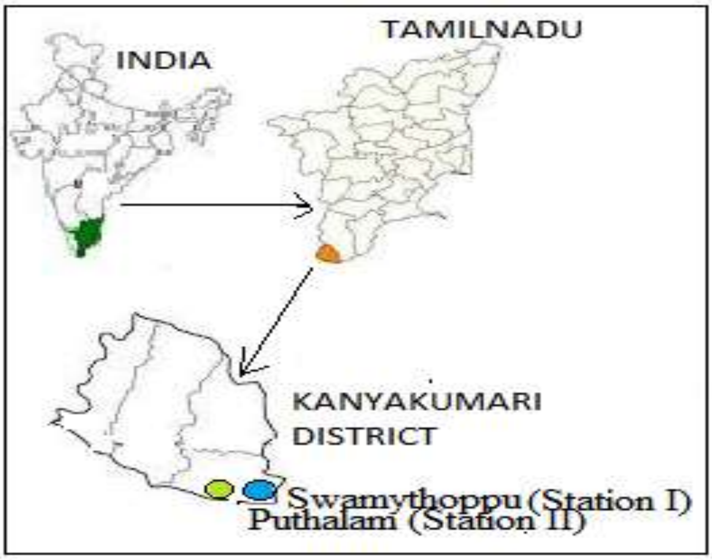

Figure 1 Map showing the study area of Swamythoppu (Station I) and Puthalam (Station II)

2.2. Sample collection

Water and *Artemia* samples were collected in sterile samples during the morning hours between 6am to 8am at fortnight basis from both study area (figure 1) for the period of one year from May 2018 to April 2019**.** The samples were collected in reservoir, condenser and crystallizer units of saltpan separately during the study period. The collected samples were packed, labeled and brought to the laboratory for the analysis of physicochemical and biological parameters.

2.3. Physicochemical parameters

The physicochemical parameters such as temperature, pH, salinity and dissolved oxygen were observed by using systronic water analyzer 371. The depth of the saltpan was measured using standard instruments. The water samples collected from different sampling stations of various ponds was brought to the laboratory for further biological analysis.

2.4. Biological analysis

The water samples were collected from different units of study area and analyzed for the population density of *Artemia* by using standard methods described by Vanhaecke and Sorgeloos (1980). The *Atremia* was preserved in 5% formalin for further biometric analysis.

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2.5. Statistical analysis

The data were subjected to two way ANOVA and Karl–Pearson correlation coefficient using Kyplot 2.0 software to establish a relationship between physicochemical parameters and different stages of *Artemia* abundance ($p \leq 0.05$).

III. RESULTS

3.1. Physicochemical parameters

The physicochemical parameters of collected water samples of reservoir pond, condenser pond and crystallizer pond were measured for each station. Physicochemical parameters of water sample viz., temperature, pH, salinity, dissolved oxygen, depth of water were analyzed. The physicochemical parameters of water samples collected from reservoir pond, condenser pond and crystallizer pond of swamithoppu (station I) were depicted in figure 2, 3 &4 respectively. Similarly samples collected from puthalam (station II) were portrayed in figure 5, 6 &7 respectively. The water samples were collected from each station was divided into 3 seasons namely pre-monsoon, monsoon and post-monsoon.

Highest temperature was recorded in both station 1 and 2 during post monsoon seasons whereas lowest temperature was recorded in station 1 and 2 in monsoon seasons during the study period. The temperature of water samples of reservoir pond, condenser pond and crystallizer pond in station 1 and station 2 faintly varied within the sampling station. Average temperature of water sample in station 1 is around 28.66ºC and station 2 is 27.99ºC during the study period. The pH of water samples showed slight variations within the sampling station. Maximum pH 8.7 (figure 3) was recorded in condenser pond during post monsoon seasons while the minimum pH 8.2 was reported in monsoon seasons in both the station. Salinity of water samples varied with respect to sampling station and various seasons (Pre monsoon, Monsoon and post monsoon). Highest salinity was reported (figure 3&7) from crystallizer ponds in pre monsoon and lowest salinity was recorded in monsoon in both stations during the entire study period. Dissolved oxygen was recorded maximum during monsoon season from both station 1 and 2 while the minimum DO was evidenced on both stations during pre monsoon and post monsoon seasons. Among the parameters studied, highest water depth was recorded from reservoir pond (figure 2&5) of both stations during monsoon than other seasons in the study period.

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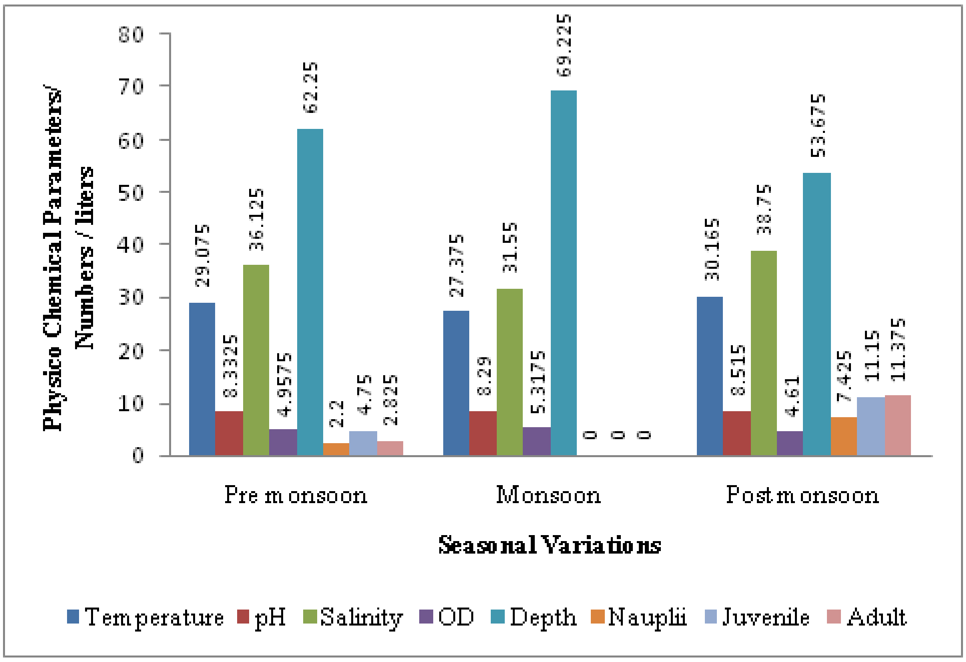

Figure 2 seasonal variation of physicochemical parameters and *Artemia* recorded in Reservoir pond at station 1

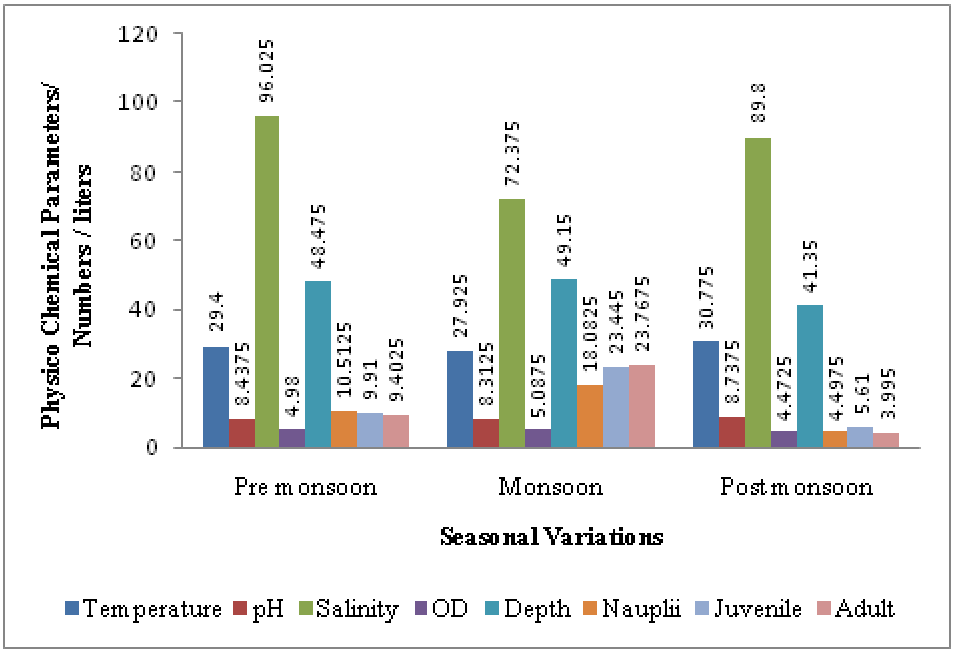

Figure 3 Seasonal variation of physicochemical parameters and *Artemia* recorded in Condenser pond at station 1

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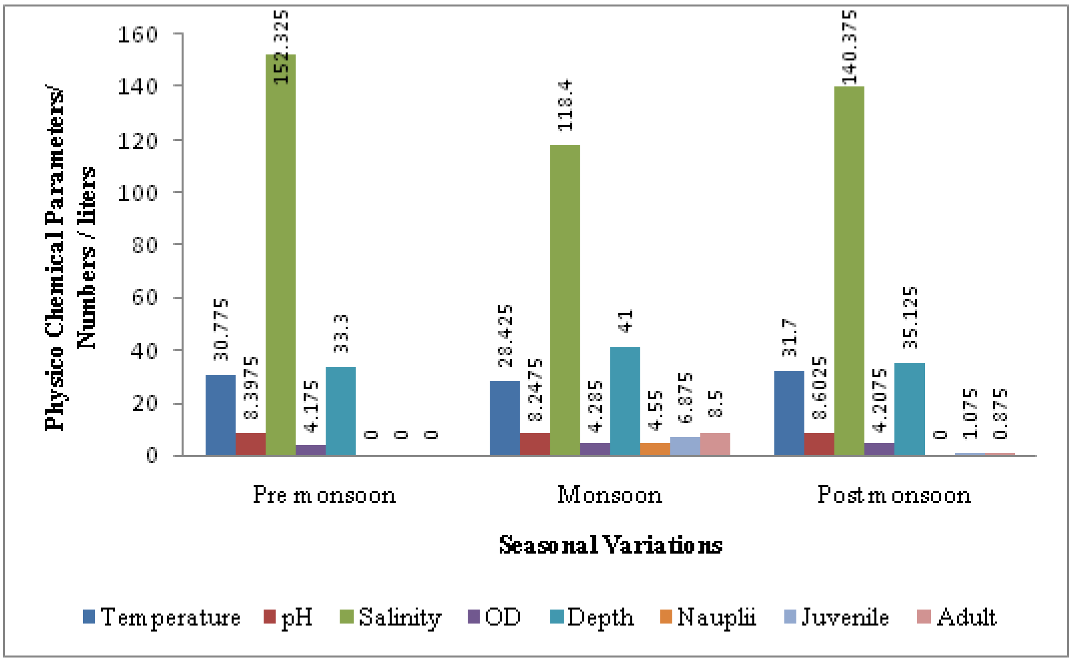

Figure 4 Seasonal variation of physicochemical parameters and *Artemia* recorded in Crystallizer pond at station 1

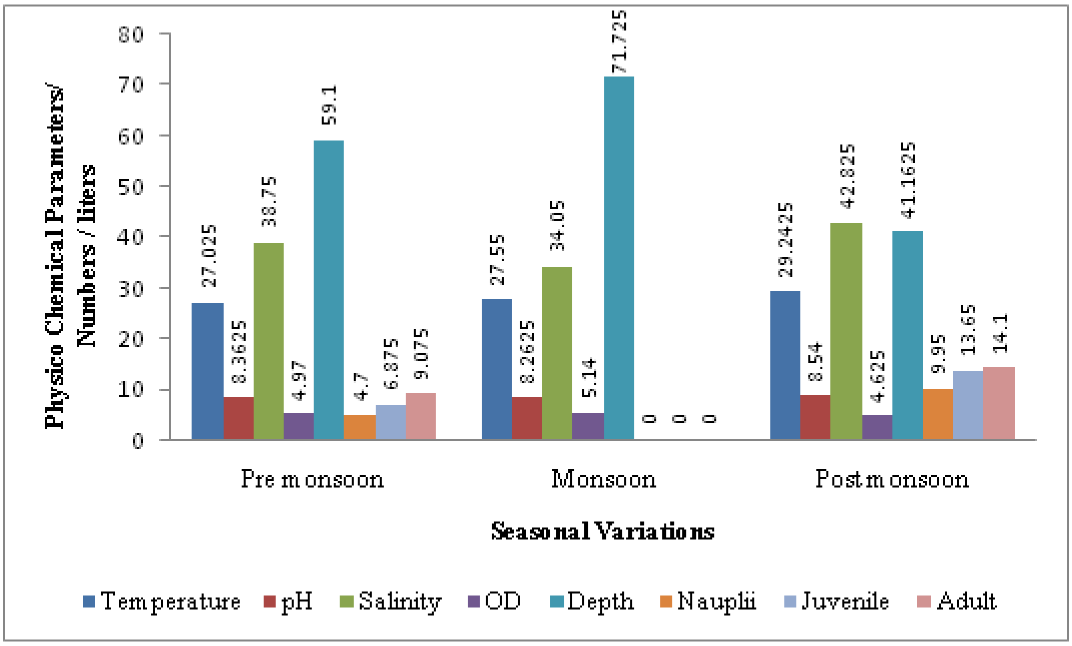

Figure 5 Seasonal variations of physicochemical parameters and *Artemia* recorded in Reservoir pond at station 2

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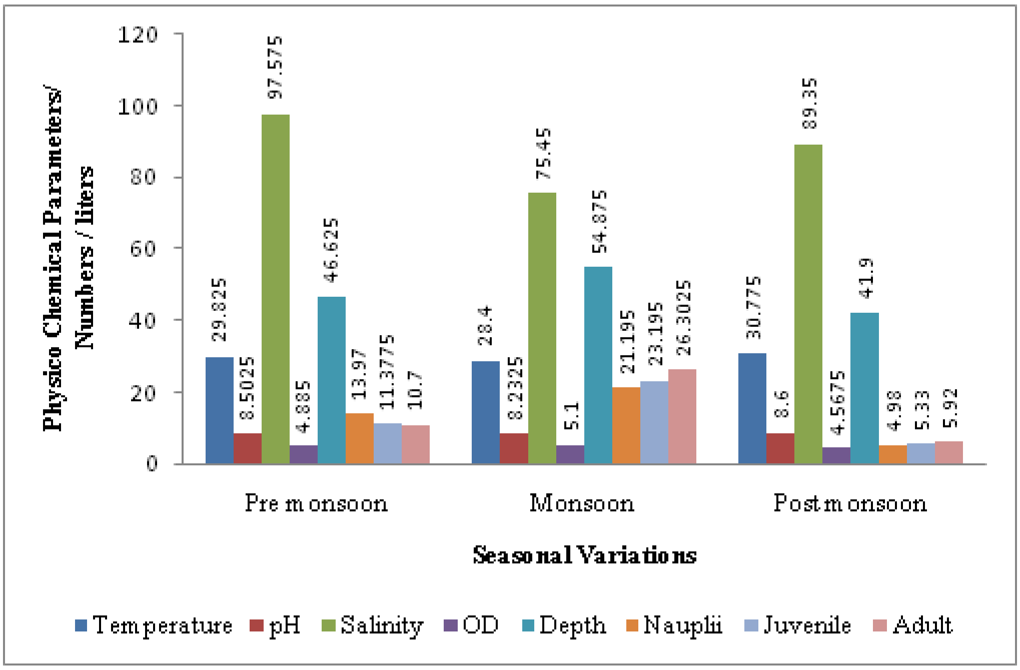

Figure 6 Seasonal variations of physicochemical parameters and *Artemia* recorded in Condenser pond at station 2

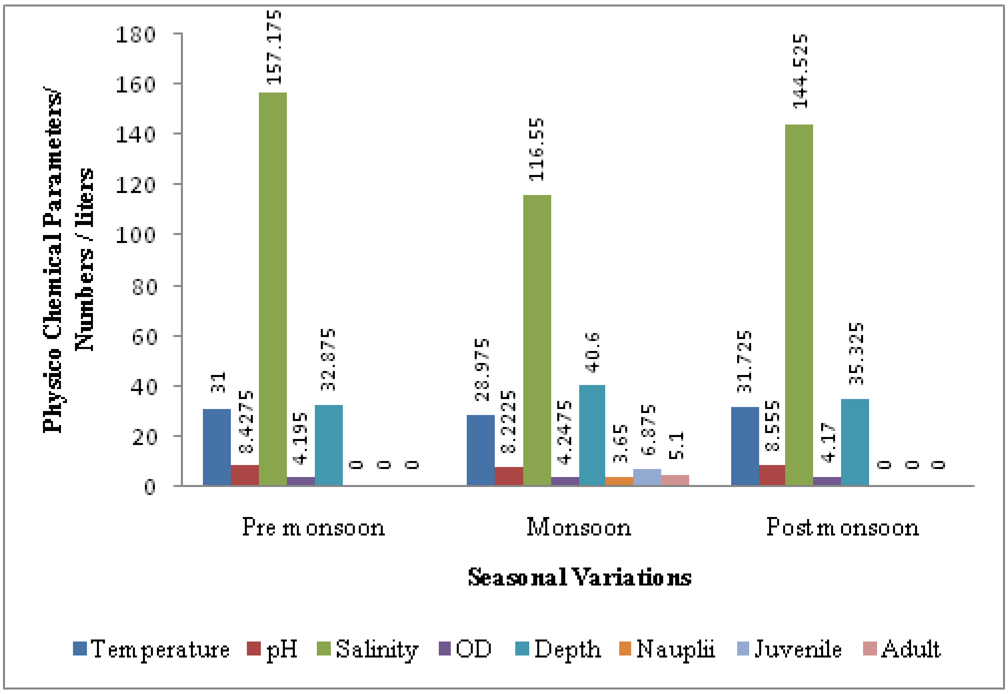

Figure 7 Seasonal variations of physicochemical parameters and *Artemia* recorded in Crystallizer pond at station 2

3.2. Artemia population

Artemia population was resolved in one liter of water samples collected from reservoir pond, condenser pond and crystallizer pond of both stations. Different growth stages of Artemia viz., naupli, juvenile and adult of station 1 is presented in figure 2, 3 & 4 and station 2 is showed in figure 5, 6 & 7 respectively. Highest Artemia population of 11.375 (figure 2) and 14.1 (figure 5) was reported in post monsoon seasons of sample collected from reservoir pond of station 1 and 2 respectively while no *Artemia* population was recorded in monsoon seasons and crystallizer

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pond in pre monsoon seasons. The results insisted that the ideal season for the collection of *Artemia* is post monsoon season from reservoir pond.

Table 1: Correlation coefficient among physicochemical parameters and *Atremia* richness in station 1

Sampling units	Parameters	1	2	3	4	5	6	7	8
Reservoir pond	Temp	1							
	pH	0.891	1						
	Salinity	1.000	0.878	1					
	Dissolve oxygen	-0.993	-0.938	-0.990	1				
	Depth	-0.983	-0.960	-0.977	0.998	1			
	Naupuli	0.937	0.994	0.926	-0.971	-0.98	1		
	Juvenile	0.978	0.966	0.971	-0.995	-1.00	0.989	1	
	Adult	0.918	0.998	0.906	-0.957	-0.97	0.999	0.981	1
Condenser pond	Temp	1							
	pH	0.968	1						
	Salinity	0.725	0.529	1					
	Dissolve oxygen	-0.929	-0.992	-0.418	1				
	Depth	-0.894	-0.97	-0.338	0.996	1			
	Naupuli	-0.999	-0.95	-0.756	0.911	0.872	1		
	Juvenile	-0.964	-0.86	-0.882	0.796	0.741	0.975	1	
	Adult	-0.972	-0.88	-0.866	0.817	0.764	0.982	0.999	1
Crystallizer pond	Temp	1							
	pH	0.944	1						
	Salinity	0.807	0.567	1					
	Dissolve oxygen	-0.842	-0.61	-0.998	1				
	Depth	-0.875	-0.66	-0.992	0.998	1			
	Naupuli	-0.962	-0.81	-0.938	0.958	0.974	1		
	Juvenile	-0.912	-0.72	-0.978	0.989	0.997	0.989	1	
	Adult	-0.932	-0.76	-0.966	0.980	0.991	0.996	0.999	1

Correlation is significant at the 0.05 level (2 tailed)

Table 2: Correlation coefficient among physicochemical parameters and *Atremia* richness in station 2

Sampling units	Parameters	1	2	3	4	5	6	7	8

Reservoir pond	Temp	1							
	pH	0.830	1						
	Salinity	0.702	0.980	1					
	OD	-0.848	-0.999	-0.973	1				
	Depth	-0.795	-0.998	-0.990	0.996	1			
	Naupuli	0.752	0.992	0.997	-0.987	-0.998	1		
	Juvenile	0.727	0.987	0.999	-0.980	-0.995	0.999	1	
	Adult	0.609	0.948	0.992	-0.937	-0.965	0.981	0.987	1
Condenser pond	Temp	1							
	pH	0.989	1						
	Salinity	0.707	0.805	1					
	OD	-0.975	-0.930	-0.531	1				
	Depth	-0.999	-0.994	-0.735	0.965	1			
	Naupuli	0.339	0.195	-0.425	-0.541	-0.301	1		
	Juve	-0.998	-0.997	-0.755	0.957	1.000	-0.27	1	
	Adult	-0.983	-0.999	-0.824	0.918	0.990	-0.16	0.994	1
Crystallizer pond	Temp	1							
	pH	0.991	1						
	Salinity	0.844	0.765	1					
	OD	-0.998	-0.998	-0.808	1				
	Depth	-0.840	-0.761	-1.000	0.804	1			
	Naupuli	-0.967	-0.925	-0.953	0.949	0.951	1		
	Juve	-0.967	-0.925	-0.953	0.949	0.951	1.00	1	
	Adult	-0.967	-0.925	-0.953	0.949	0.951	1.00	1.00	1

Correlation is significant at the 0.05 level (2 tailed)

The results of correlation coefficient of various physicochemical parameters against *Artemia* population in Reservoir, Condenser and Crystallizer ponds at station 1 is displayed in table 1 and for station 2 is presented in table 2. The parameters such as temperature, pH, salinity, dissolved oxygen and depth of water significantly influence the population of *Artemia* in reservoir pond at station 1. But only temperature and pH notably influenced the population of *Artemia* in condenser pond at station 1. However parameter such as temperatures, salinity, dissolved oxygen and depth of water significantly influenced the abundance of *Artemia* population in crystallizer pond at station 1. The parameters like pH, salinity and dissolved oxygen were considerably persuading the population of *Artemia* in reservoir pond (Table 2) while in condenser pond, parameters such as temperature, pH, dissolved oxygen and depth of water evidently influenced the abundance of *Artemia* population (Table 2) in station 2. However parameters such as temperatures, pH, salinity, dissolved oxygen and depth of water were found to extensively influence the abundance of *Artemia* population in crystallizer pond (Table 2) at station 2. *Artemia* population was significant ($p > 0.05$) in post monsoon seasons and sampling units at station 2. The various stages of *Artemia* population were non-significant ($p > 0.05$) in seasons and sampling site at both study area.

IV. DISCUSSION

The physicochemical and hydrological parameters of hyper saline water play a significant role for the development of biological community of saltpan ecosystems (Davis 2000). The recent climatic changes have led to increasingly intense monsoon rains in some regions drastically and to decreasing rainfall levels in others (Das Sarma 2007). The unstable climatic conditions may severely influence the life forms of various ecosystems on the earth's crust. Biological community of saltern ecosystems are highly influenced by physicochemical characters due to seasonal variations.

Helan Soundra Rani & Kalaiselvam (2018) reported that diverged temperatures were recorded at different stations. Highest temperature was observed during summer due to intense solar radiation which may heat the brine water of shallow salterns ponds resulting in rapid evaporation of water for sudden crystallization process. Petrovic (1998) observed that slight increase in brine temperature from reservoir to crystallizer ponds which greatly collaborate with the present study.

Van Stappen (2002) reported that *Artemia* can sustain and survive wide range of temperature from 6ºC to 35ºC with diverse ionic salt concentration. But in our study the temperature ranged only between 29ºC to 31ºC and hence not much variation in temperature was experienced. But the salt concentration varied from 31ppt to 152 ppt and the ideal salinity was found to be 72ppt where there was abundance of *Artemia* population of all stages. *Artemia* can tolerate towards water pH from neutral to hyper alkaline condition by metabolic adaptation. As a result, the differences in physicochemical characteristics of hypersaline water such as temperature, pH, salinity and dissolved oxygen strength play vital role on the variation of *Artemia* populations (Camargo et al. 2004)

The pH of water from reservoir ponds increases corresponding to increasing concentration of iron oxide and calcium carbonate. There is a slight decrease in the pH at condenser and crystallizer ponds due to the removal of salts before the brine pass on to the condenser ponds (Femitha & Vaithyanathan, 2012). Vos & De La Rosa (1980) suggested that the optimum pH for *Artemia* growth was from 8.0 to 8.5 in salt pan ecosystem. In our study, the pH is to hold up to 8.7 with affecting the growth of *Artemia.* However, when the pH decreases below 7.0 the morphology of adult *Artemia* deteriorates and naupli growth also decreases. This result agreed with the present salt work of both study sites. Subramanian & Kannan, (1998) observed that low pH was recorded during monsoon seasons due to influx of fresh water and dilution of brines. Similar results were obtained in our study during monsoon seasons inflow of fresh water took place heavily. Patadia & Dave (2015) evident that pH of water collected from salt pan at Newport situated around Bhavnagar coast was found to be slightly alkaline during pre monsoon and post monsoon seasons while around neutral pH was recorded during monsoon season. Furthermore, pH of water sample was higher at Newport than at Nari. But in the present investigation almost equal pH was recorded at both study sites during the study period.

Abatzopoulos et al. (2003) observed that decline in the population density of *Artemia* during the summer season due to evaporation of water induce high salinity stimulate a reduction in the fertility of the females. The influx of fresh water during the monsoon season brings down water salinity and temperature and enhances population development. The physicochemical factors including temperature, pH, salinity and DO were optimized by inflow of water which activated the hatching of *Artemia* cysts and increased their reproductive rate. Balachandar et al.

(2017) suggested that salinity of saltpan ecosystem influences the planktonic population. The diminishing population of *Artemia* may occur due to high water salinity, temperature and low availability of food. The population density increased in post monsoon seasons by the supply of fresh underground water and reducing salinity at both study stations.

Naceur et al. (2011) reported that strong correlation coefficients were found between physicochemical parameters of water from saltpan and *Artemia* reproduction. But no major relationship was identified between physicochemical factors and *Artemia* population structure and density. In contrast the present study physicochemical parameters of saltpan water at both study station and seasonal variation highly influence the population density of *Artemia*. However reproductive ability was not studied in the present investigation so it is premature to comment on the correlation between reproductive and physiochemical parameter at this stage.

V. CONCLUSION

During the study period it demonstrated that the prevalent *Artemia* population was influenced by physicochemical and hydro biological parameters of saltpans ecosystem. It is observed that the inflow of rain water into saltpan brine water during post monsoon seasons flourished the growth of *Artemia* on all salinity ranges. Hence the present study concluded that among different seasons, post-monsoon season is most suitable for the collection of brine shrimp *Artemia* for aquaculture industry by supplying green water. In addition, the present investigation provides significant information on the relationship between physicochemical parameters and biological counterpart of brine shrimp *Artemia* of the salt pan ecosystem along the Cape comorin coast.

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VII. CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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