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Brine Pans of Mumbai: A Wellsprings for Blue Economy as a Fish Meal Culture in Hyper Saline Areas of Mumbai, India

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Abstract Several studies explored the importance of integrated salt-production and possibilities of fish meal cultivation during salt farming along the coast of Arabian Sea from the month of November to Mid-June. Hundreds of acres of land in Mumbai, would be converted into a high economical fertile zone by introducing zooplankton culture as a fish meal. This is an opportunity to develop blue economy for a populous country like India. The present research included monthly hydrological analysis and the study of zooplankton distribution in bhandup salt-pans, Mumbai. The brine environment has been studied through a dataset and comprising the taxonomic composition of zooplankton in 5 different regions in a series of bimonthly sampling for 8months. Economically important species of Zooplankton, found abundant in salt pan and are recommended for cultivation due to their high demand as a live fish feed such as *Fabrea salina (Henneguy, 1890)* it is ranging from (4942-125913 Ind/l), i.e. ("Individual per litre") *Artemia salina (Linnaeus,1758) it ranges from* (1041.8- 4292 Ind/l), Copepods 102042- 174832 Ind/l), etc.

Keywords: *zooplankton, aquaculture, sustainable development, Artemia salina, Fabrea salina*

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1. Introduction

The blue economy is the "sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of the ocean ecosystem" [1]. The objective of the Blue Economy is to promote smart, sustainable, and inclusive growth and employment opportunities within the maritime economic activities. The Blue Economy is determined to initiate appropriate programs for; the sustainable harnessing of ocean resources; research and development; developing relevant sectors of oceanography; stock assessment of marine resources; introducing marine aquaculture, deep-sea/long line fishing, and biotechnology; and human resource development; among others [2]. The importance of zooplankton as a main source of nutrition of marine fish larvae has been long professed. Many scientists attributed the ability of a fish population to outdistance through the larval period without vast mortality as one of the primary factors determining the size of the resulting year class and hypothesized that competition for food during the larval time might be a major factor affecting survival and subsequent year-class strength [3].

Fish meal is one of the components of the blue economy (marine product) and able to provide job opportunities to local people and open a new avenue for entrepreneurs. The India Aquaculture Feed Market was valued at USD 1.20 billion in 2017 and is expected to register a CAGR (Compound Annual Growth Rate) of 10.4% during the forecast period (2018-2023). India feed mills can produce 2.88 million metric tons. Andhra Pradesh is the largest feed consuming state in India. The coastal line of the country is about 7,517 kilometres with 195.20 kilometres of river and canal systems. The country consists of 14 rivers, 44 medium rivers, and many small rivers. The country also has tanks and ponds. From these sources, it is clear that the aquaculture industry is huge in India which provides huge opportunities and potential for the aquaculture feed industry [4]. As aquaculture production increases with feed intake and waste, the amounts of organic matter, nutrients, and suspended solids also increase [5].

The global fishmeal market is anticipated to show significant market growth during the 2017-2027 forecast period. The market experienced consistent growth from 2012 till 2016. In 2017, the global fishmeal market was valued a bit under US$ 6 Bn and is estimated to reach a valuation of approximately US$ 10 Bn by the end of the assessment. The global fishmeal market is projected to grow at a high-value CAGR of 5.2% throughout the assessment, 2017-2027. The main factors contributing to the growth of the global fishmeal market are rising demand for naturally sourced protein additives in animal feed, expansion of feed industry, extensive salmon aquaculture farming, rising number of individuals inclined towards non-vegetarian dishes, and increased consumption of fish as a major food in various regions in the globe. Concerning volume, the global fishmeal market is poised to grow at a 4.5% CAGR during the forecast [6].

2. Methodology

2.1. Study Site

Bhandup Salt-work is one of the largest salt-work of Mumbai, based at the banks of Thane creek, connected to the Arabian sea of Indian Ocean. The entire Salt-pan plant is covering an area of about 500 acres. The latitude and longitude coordinates of selected are 19.140862, 72.949278. The present study was conducted in Jenkin salt works, which is part of Bhandup Salt-work, which lays both sides of the eastern highway (Mumbai -Nashik Road). Salt curing in saltpans takes place from November to June and crude salt is extracted during summer. During the remaining part of the year, the area remains barren and no other activity is conducted.

Salt pans consist of series of rectangular beds, here we will be termed as Region 1 to Region 5 (R1 - R5) each bed bounded on all four sides and joined to the next one through an opening in the common bund. A sluice gate in one bund of the first bed (R1) allows the influx of saline water from a creek during high tides. Here the water is allowed to evaporate and acquire a high density and specific gravity, after fortnight it transfers to another pan (R2), this process keeps going till it reaches to crystallizer (R5) where it crystallizes and salts are collected at the platform.

2.2. Period of Experiment

The present study was carried out for 8 months of salt production season from November 2013 to June 2014 at 5 different regions (R1 to R5) of Jenkin salt pans at Bhandup, Mumbai, Maharashtra, India.

2.3. Sampling Procedures

The water samples for physicochemical analysis were collected every fortnight from 5 sampling stations in acid-washed plastic bottles from a depth of 5-10 cm below the surface of the water. The standard methods were adopted for the estimations of salinity, dissolved oxygen, free dissolved CO2. Biochemical Oxygen Demand (B.O.D) and concentrations of phosphate, nitrite, nitrate, and silicate. To determine the density of water a specially designed Baumé hydrometer (Cimco) was used. Cimco hydrometer was used in the field. It consists of a mercury bulb at the base and a stem which shows specific gravity marking from 1 to 2 on one side and corresponding 0 Bé° (Baume scale) from 0 to 70 on the other side. The specific gravity and density of water effect on salt production and salinity of water. Both the values were obtained directly from the hydrometer. The specific gravity gradually increases from 1.027 to 1.20 from R 1 to R 5 so also density that is represented by Bé°. It increases from main reservoirs up to pans from 3 to 26.5 0 Bé°. At low concentrations, Baumé Hydrometer gives an almost accurate assessment of NaCl content but at higher densities, as the brine gets enriched with other salts, the reading does not represent the sodium chloride alone. The temperature of water samples was measured by good quality centigrade thermometer immediately after collections. pH was measured on a battery-operated Philips pH meter. The instrument was calibrated with a standard buffer just before use.

2.4. Estimation of Zooplankton

Samples for Zooplankton were collected in 500ml polythene bags. They were preserved in 8% buffered formalin. At the time of counting, the images of the microscope field were video-recorded and then processed in both Kontron IBAS-1 and IBAS-2000 (semi-automatic mode) image analysers to obtain different biometric parameters: major diameter (D) as the longest distance between the two extremes of the organisms, and minor diameter (d) as the width of the mean cross-section (longest perpendicular distance between two points at the edge of the organisms).

2.5. Inclusive Opportunity to India

There are thousands of saltpans located on both coasts of India occupying more than hundreds of thousands of acres of coastline. Many larvae feed on zooplankton, one is the carp larvae feed mainly on zooplankton, starting with small organisms (rotifers), and as they grow then shifting to larger organisms, e.g. copepods and cladocerans. As adults they are commonly benthic feeders, concentrating principally on zoo benthos (mainly chironomid larvae); however, zooplankton is also an important part of the diet, depending on food availability and spatial and temporal variation [7].

The purpose of the study also includes providing a model of integrated salt -farming, zooplankton production as a fish meal from aquaculture industries, and for aquarium during the salt-production period.

3. Results and Discussion

3.1. Data of Hydrological Analysis

The hydrological analysis shows that R1, R2, and R3 areas are enriched in nutrients like nitrite (NO^2) (Avg.7.5 µg/l), nitrate (NO^3) 3.2 µg/l, and silicate 3.4 µg/l, Salinity was average at 44 ppt and temperature 32°C throughout the salt-production period. This shows, Salinity and temperature plays a dynamic role in hydrological parameters and it is having SD 139.12 and 10.24 respectively. Resulting in diverse number of Zooplankton population in these three zones (i.e.) R1, R2 and R3. Hydrological conditions in R4 and R5 were found extreme fatal in these zone.

Table 1. Results of hydrological parameter of Salt-pans

Parameters	R1(AV)	R2(AV)	R3(AV)	R4(AV)	R5(AV)	Mean	SD
Dissolve oxygen mg/l	2.94-4.62V	1.98-4.50	1.25-4.35	0.96-1.89	0.15-1.25	2.67	1.72
Free carbon di-oxide mg/l	3.92-4.75	2.85-4.30	2.85-4.50	2.35-3.40	1.10-2.80	3.83	1.21
Biochemical oxygen demand mg/l/d	4.05-4.60	2.94-5.64	4.92-6.15	0.66-1.11	0.01-0.33	3.45	2.67
Phosphate μg/l	2.75-7.55	2.05-7.85	1.10-6.25	0.60-2.10	0.15-0.87	3.94	3.33
Silicate μg/l	2.00-4.44	2.20-4.85	1.45-3.85	0.94-1.73	0.25-0.68	2.31	1.66
Nitrate μg/l	13.75-18.65	10.20-20.90	5.15-17.40	2.13-7.65	1.08-4.20	1.52	0.84
Nitrite μg/l	1.65-3.60	1.48-4.00	0.89-2.97	0.70-1.40	0.15-0.68	9.076	7.47
Temperature (C^0)	23.55-31.40	23.30-34.00	23.20-35.55	27.30-40.10	31.40-51.35	38.4	10.24
pH	7.05-8.00	7.05-7.80	7.05-7.77	6.40-7.30	6.05-6.80	7.24	0.49
Salinity (PPT)	24.47-50.63	27.70-57.65	32.35-98.01	88.95-234.00	232.49-556.22	129	139.12

3.2.1. Zooplankton Diversity of Saltpan

The zooplankton of the salt pans was recorded at five different sampling stations which consist of *siphonophores*, *medusa*, amphipods, crustacean, fish larvae, copepods, polychaetes, *Chironomus*, *copelates*, decapods, oshacods, *fabrea salina*, *ostiacods*, Platyhelminthes, *cladocerans*, chetognaths, bivalve, fish egg, isopods, stomatopod, gastropod, *mysids*, ctenophores and *Artemia*.

The dominant zooplankton diversity is listed in Table 2. Copepods, *Fabrea salina*, *Artemia*, Chaetognaths, and mysids are found to be the most abundant zooplankton of Bhandup salt-pans. Most of the physio-chemical factors are positively correlated with these plankton (Table 3 a &b).

Table 2. List of abundant species of Zooplankton (individuals/lm3) in different stations of Salt-pans

Sr. No.	Zooplankton	R1	R2	R3
1	*Siphonophores*	393	274	170
2	*Medusa*	2949	720	63
3	*Amphipods*	176	39	15
4	Crustacean	2762	3761	123
5	Fish Larvae	959	676	77
6	Copepods	174832	102042	38641
7	Polychaetes	280	165	10
8	*Chironomus*	125	12	76
9	Decapods	76760	19524	1056
10	Ostracods	34	5	4
11	*Fabrea Salina*	4942	147943	125913
12	Platyhelminthes	7.5	1.5	1.5
13	Chaetognaths	11171.5	4826	9480.5
14	Bivalve	561.5	263.5	15
15	*Artemia*	1041.8	4292	2176.7
16	Isopods	56	16	14
17	Stomatapod	478	58	12
18	Gastropod	24	12	8
19	*Mysids*	2246.5	4514.4	2246.5
	Average total zooplankton.	32167.4	32150.4	3126.29
	Standard Deviation (SD)	17793	25959.3	7011.63

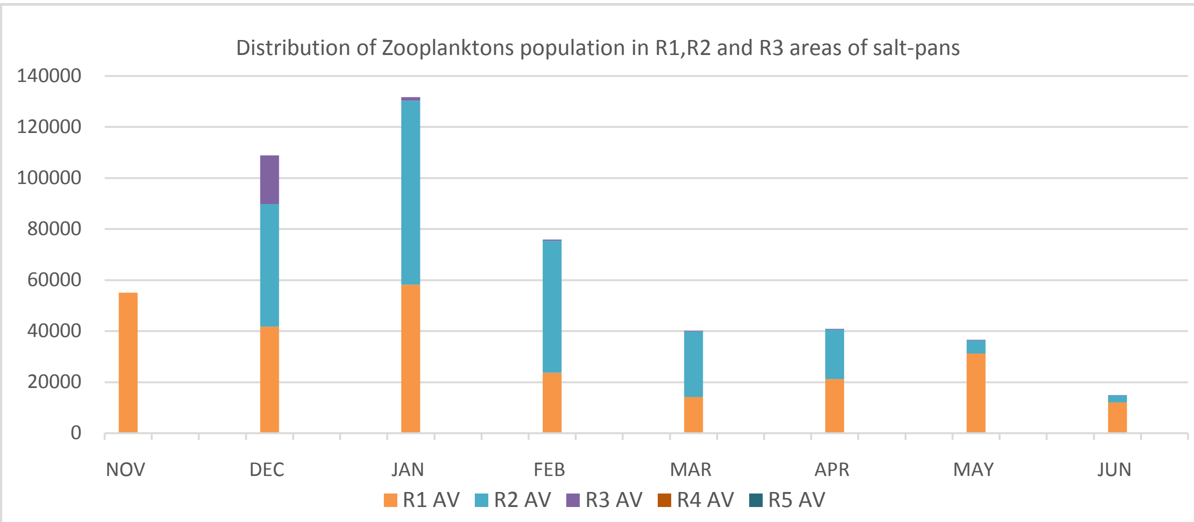

Figure 1. Distribution of different Zooplankton were studied with respect to Coefficient correlation of hydrological parameters

The zooplankton diversity of population was recorded at all stations during the 8 months of the study periods. The population diversity of zooplanktons was analyzed. R1 and R2 regions of salt pans have higher number of Zooplankton (Figure 1). R2 and R3 areas are suitable for zooplankton culture. It was observed that the average zooplankton population diversity was 72173.00 x10^3/L as highest in January and 212 x10^3/L as the lowest in June, as recorded in Figure 1.

Earlier work has shown that temperature is an important factor influencing the growth of the zooplankton community [8]. Zooplankton provides the main food for fishes and can be used as indicators of the tropic state of the water bodies. Hydro-biological conditions of the solar salt works were influenced by the tidal Oscillations. The higher saline habitats are characterized by large tidal changes in temperature and dissolved oxygen [9].

Coefficient correlation studies show that most of the physio-chemical factors are favourable for the zooplankton community. Dissolved oxygen, nutrients, pH are positively correlated while temperature and salinity are limiting factors for the planktonic population of the brine ecosystem (Table 3).

Table 3 (a). Coefficient correlation: results show that hydrological parameters are more favourable to the above species compared to others

Parameter	Siphono phores	Medusa	Amphi pods	Crustacean	Fish Larvae	Copepods	Poly Cheats	Chironemou s Larvae	Cope lates	Decapods	Oshacods	Fabria salina	Ostia Cod	Platyhelmint hes
D.O	0.851	0.801	0.785	0.768	0.885	0.937	0.868	0.342	0.868	0.802	0.758	0.389	0.769	0.823
CO_2	0.814	0.789	0.775	0.713	0.848	0.909	0.836	0.283	0.840	0.789	0.752	0.355	0.761	0.804
B.O.D	0.618	0.548	0.526	0.610	0.672	0.755	0.634	0.411	0.631	0.546	0.499	0.639	0.510	0.566
PO_4	0.919	0.822	0.807	0.863	0.944	0.967	0.923	0.426	0.915	0.825	0.771	0.375	0.786	0.859
Silicate	0.818	0.661	0.641	0.845	0.852	0.873	0.810	0.568	0.793	0.664	0.597	0.572	0.615	0.709
NO^2-N	0.918	0.826	0.810	0.858	0.943	0.967	0.923	0.417	0.916	0.828	0.775	0.368	0.789	0.861
NO^3-N	0.878	0.765	0.748	0.848	0.907	0.934	0.879	0.469	0.869	0.768	0.710	0.452	0.725	0.804
Temp	0.618	0.548	0.526	0.610	0.672	0.755	0.634	0.411	0.631	0.546	0.499	0.638	0.510	0.566
Ph	0.842	0.834	0.819	0.720	0.876	0.942	0.868	0.252	0.875	0.833	0.798	0.325	0.807	0.845
Salinity	-0.584	-0.487	-0.470	-0.598	-0.623	-0.671	-0.588	-0.418	-.580	-0.488	-0.440	-0.535	-0.452	-0.515

Table 3 (b). Coefficient correlation: results show that hydrological parameters are more favourable to the above species compared to others

Parameter	Clodecerans	Cheatognaths	Bivalve	Artemia	Isopod	Somatopod	Gastropod	Mysid	Ctenophores
D.O	0.900	0.836	0.823	0.576	0.886	0.756	0.960	0.952	0.824
CO_2	0.876	0.813	0.807	0.525	0.877	0.752	0.924	0.914	0.773
B.O.D	0.685	0.5827	0.572	0.695	0.703	0.505	0.938	0.827	0.654
PO_4	0.933	0.878	0.851	0.613	0.876	0.763	0.967	0.990	0.908
Silicate	0.815	0.737	0.697	0.758	0.746	0.589	0.982	0.950	0.872
NO^2-N	0.934	0.880	0.853	0.606	0.879	0.767	0.964	0.988	0.904
NO^3-N	0.890	0.826	0.796	0.665	0.835	0.703	0.978	0.976	0.888
Temp	0.685	0.582	0.572	0.695	0.703	0.505	0.938	0.827	0.654
pH	0.912	0.852	0.849	0.503	0.920	0.800	0.937	0.935	0.786
Salinity	-0.614	-0.533	-0.513	-0.624	-0.596	-0.440	-0.810	-0.739	-0.628

At Bhandup salt-pans we found that the mean density of copepods was in the R1 region 174832/l, R2 region 102042/l and R3 Region 38641/l. The relationship between the correlation coefficient and the jump degree of series were described using mathematical equation by derivation. Results of coefficient correlation [10] show that copepods have the most positive correlation with hydrological factors of selected salt-pans in comparison with any other planktons found in this saltpan.

3.3. Major Zooplankton Can be Culture in Salt-pans

3.1. Fabrea Salina

Fabrea salina has been found abundantly in the Bhandup Saltpans. Mean population of *F. salina* was at R1- 4942/l, R2 -147943/l, and R3-125913/l ("Individuals per litre"). Results showed their dominance in the research area due to favourable ecological factors and an abundance of food. Since the last three decades, many researchers have recommended the use of these ciliates as live fish meal for aquaculture and also on commercial cultivation of it. Most of these research works suggested that due to its size, fish larvae prefer it as most marine fish larvae select prey ranging from 50-100 µm in width [11,12,13]. Depending on the mouth size of fish larvae, rotifers, copepod nauplii or brine shrimp have been traditionally provided to many first-feeding fish larvae in aquaculture. Natural propagation of *Fabrea salina* has been reported from several diverse environments such as salt marshes, hypersaline lakes, and solar salterns [14,15]. Its reproductive rate is high so that this ciliate has been expected to be a new food organism that will be able to replace rotifer, Brachionus plicatilis. However, the dietary value of F. *salina* on fish larvae has not yet been verified thoroughly. Salt-pans would be an ideal place for the culture of *Fabrea salina* due to suitable environmental factors, higher salinity, and the presence of diverse algal growth provides them as feed.

3.2. Artemia Salina

Artemia sp. is characteristic of hypersaline water and is well adapted to saltpan ecosystem through its ability to osmoregulation, utilization of oxygen at a low level via haemoglobin, and tolerance for a broad temperature range, It was observed that pH, nutrients, and predominance of selective phytoplankton as food like Dunaliella salina were some of the important factors controlling the distribution of Artemia in a saltpan ecosystem [16].

The distribution of Artemia in different regions of salt-pans of Bhandup was found as R1-1041.8 /l, R2-4292/l and in R3-2176/l. Artemia can be intensely cultured in evaporation ponds of the solar saltpans. Studies on a natural population of *A.salina* in the salt-pans of Tuticorin indicate these shrimps reach a maximum size of only 10 mm and attain early maturity and reproduce in 12 days. Artemia cysts match out at higher salinities of 130- 160 ppt thus suggesting that the hatchability of these cysts in nature is entirely different from laboratory conditions and might be on ecological adaptation. The potential annual yield of Artemia eggs from 1hais about 30 kg. Artemia culture is has been in commercial practice in many countries like Japan, China, USA Belgium, Vietnam, etc. for the last many years. Among the live diets used in the nauplii of the brine shrimp Artemia is considered as the most widely used fish meal. These creatures are a great source of vitamin A and vitamin D for aquarium fish.

Artemia dormant cysts can be stored for long periods in cans, and then used as an off-the-shelf food requiring only 24 h of incubation makes them the most convenient, least labour-intensive, live food available for aquaculture.

Taking advantage of its continuous nonselective feeding behavior. Hence, a diet enriched with EFA 20:5(n-3) and 22:6(n-3) will produce nutritionally more adequate Artemia [17]. Ingrown Artemia as a hatchery/nursery food resulted in significant savings of Artemia cysts of up to 60% and consequently a significant reduction in the total larval feed cost. In the early larviculture of lobster, Homarus spp., feeding biomass instead of nauplii has proven to reduce cannibalism adequately [18].

Used as live feed for Marine prawn culture (Penaeus sp.), larviculture of fish and shellfish and freshwater prawn culture (Macrobrachium sp.), marine fish culture (bream, bass, and flatfish), freshwater culture (Whitefish larvae), used as food for species reared as pets by home aquarists (Aquarium).

The finding of this research strongly recommends an artemia culture in Salt-works of Mumbai.

3.3. Copepods

These small aquatic crustaceans are very diverse and are the most numerous metazoans in the water community. Ecologically the planktonic copepods are important links in the aquatic food chain linking microscopic algal cells to juvenile fish to whales. Most free-living copepods feed directly on phytoplankton, catching cells singly. Planktonic copepods are important to global ecology and the carbon cycle. They are usually the leading members of the zooplankton and are major food organisms for small fish such as the dragonet, banded killifish, whales, seabirds, Alaska Pollock, and other crustaceans such as krill in the ocean and freshwater.

The marine copepods are considered being "nutritionally superior live feeds" for economically valuable cultivable species, as they are a valuable source of protein, lipid (especially HUFA, 20:5 n-3, and 22:6 n-3), enzymes (amylase, protease, exonuclease, and esterase), which are essential for larval survival, growth, digestion and metamorphosis [19,20,21]. Copepods are known to have greater digestibility [22] and relatively high weight-specific caloric content [23]. In aquaculture, copepods have been proven to be the preferred and most adequate food for many marine fish larvae [24] and are also used for shrimp larvae and postlarvae [25]. The significant results in terms of fish larval growth and survival using natural plankton are due to the presence of copepods and their role as the main food component [26]. Therefore, developing nutritionally superior live feeds is essential to produce the quality of fish larvae for successful aquaculture production. Nutritional compounds such as n-3 fatty acids, essential amino acids (EAA), and protein content of live feeds are critical factors for the survival and optimal growth of larval finfish and crustaceans. Hence the need for developing copepod gains importance. Copepods are very nutritious larval feeds, containing more EPA and DHA. Copepods also have the highest DHA to EPA ratio [27,28].

The use of copepod nauplii as live prey for first-feeding marine fish larvae is enabling the culture of many marine fish species with small, difficult to rear larvae. Copepods have higher nutritional value than Artemia and are better for meeting the nutritional requirements of marine fish larvae [29]. Copepods are a good source of proteins, amino acids, fatty acids, vitamins, and minerals. Their typical zigzag movement, followed by a short gliding phase, is an important visual stimulus for fish larvae

3.4. Caprellids

It belongs to amphipods are mostly detritivores or scavengers. There are more than 9,900 amphipod species so far described. Amphipods are poor swimmers, being highly modified as bottom crawlers and scavenging macrophages.In this context, a promising feedstuff alternative could be proved to be the marine amphipods of the Caprellidae Family. These marine organisms have recently attracted the scientific interest of aquaculture researchers, as they are rich in animal protein and at the same time contain significant amounts of the, rarely found in nature, omega-3 fatty acids [30]. Caprellid amphipods have several suitable characteristics which make them a potential feed source in aquaculture: They have a widespread global distribution and can be easily found as dominant species in fouling communities attached to sea cages structures.They consist part of the natural diet of several marine fish species, They exhibit high reproduction performance, fast growth rates, and under appropriate conditions can reach high biomass. They are opportunistic feeders, tolerant of a wide range of environmental fluctuations thus simplifying their potential culture. Caprellid amphipods have been proposed as an alternative food source in aquaculture [31]. The limited dispersal capabilities due to the lack of larval stages suggest that the cosmopolitan distribution of Caprellid amphipods are associated with their fouling nature on floating objects (natural or artificial flotsam) and commercial or recreational vessels [32].

3.5. Mysids

Mysids are small shrimp-like crustaceans that occur in marine, brackish, and freshwater from shallow to great depths. They are generally considered benthic or epibenthic, although a few species are truly pelagic, with a few species reported as commensals with hermit crabs or anemones.

Many benthic species make daily vertical migrations into higher parts of the water column. Mysids are filter feeders, omnivores that feed on algae, detritus, and zooplankton. Some mysids are cultured in the laboratory for experimental purposes and are used as a food source for other cultured marine organisms. They are sensitive to water pollution, so are sometimes used as bioindicators to monitor water quality.

The distribution of marine mysids is mainly regulated by salinity, temperature, oxygen concentration, and the depth of the water column [33]. In current salt pans Mysids are found very abundantly the mean value was R1-2246.5/l, R2 -4514.4 and In R3 -2246.5/l. Mysids are one of the major constituents of zooplankton, occupying a wide variety of aquatic environments. They play an important role in the ecological system and their role in the food chain which has been well documented [34]. All these fish meal productions needed integrated Salt-farming techniques in Mumbai salt-pans, it will create employability and help in the development of socioeconomic positions of local salt-workers. It will create additional support for the blue economy of the country.

In salt-pans, R2 and R3 areas are most suitable for the culture of zooplankton as fishmeal. A separate adjacent smaller pond can be constructed for the Zooplankton culture of an area 5m X 2m X 1m with a regular flow of brine water from adjacent pans. Mysids are easily reared in large-scale laboratory settings, and some species are commonly used as a food source for cephalopods and fishes such as seahorses. Mysids have also become common model systems in developmental and environmental toxicology studies, leading to a large body of literature on how to rear and maintain mysids in laboratory settings [35,36,37,38].

There are five important reasons for integrated salt farming in this particular area i.e. Physico-Chemical analysis results show that the first three regions are highly suitable for the production of crustacean zooplankton mentioned above. Mumbai itself is a big market hub for the fish meal. Many of Zooplanktons are occurring naturally without any boosters. Salt-production cycle matches with the Life cycle of most of the plankton. The presence of an abundant number of zooplankton, good light intensity, and low depth causes the most productive environment of the phytoplankton as well as for zooplankton itself.

Zooplankton as a fish meal for sustainable development in areas of salt pan.

Zooplanktons is the group of microscopic heterotrophic animal components of the aquatic system which have no resistance to currents, move at the mercy of the water movements, and are suspended in open or pelagic waters. They play an integral role in transferring energy to the consumers hence, form the next higher trophic level in the energy flow after phytoplankton. They occupy an intermediate position in the food-web and mediate the transfer of energy from lower to higher trophic levels [39]. The heterotrophic activities of zooplankton organisms initially handle and manage the biogenic organic materials of primary and secondary production to a considerable extent, zooplankton communities respond to a wide variety of disturbance including nutrient loading [40].

Zooplankton is strongly influenced by all the physical and chemical processes and is often used as models for ecological paradigms. Their communities are highly sensitive to environmental variations. Several parameters like pH, temperature, total alkalinity, light intensity, dissolved oxygen, changes in the climate, availability of food, predation, and competition affect the zooplankton community. Zooplankton community often responds quickly to environmental change because most species have a short generation time. They also act as bio-indicators of the health of the aquatic ecosystem and the tropic ecosystem [41]. The major groups of zooplankton in salt-pans are Protozoans, Rotifers, Cladocerans, and Copepods. Low depth of the pans, an abundance of phytoplankton, brine water, nutrients enrich the environment and favourable hydrological factors cause a high number of zooplankton population in Salt-pans. Zooplankton diversity is one of the most important ecological parameters in water quality assessment.

4. Conclusion

Despite having a good affinity of hydrological factors and other environmental features towards biodiversity, unfortunately, nowadays saltpans are often not managed and abandoned for the rest of the years. Human activities such as habitat destruction, encroachments along with climate changes impacts such as the sea-level rise and coastal erosion, affect the existence of these ecosystems and their ecological values.

Only good practices can protect exceptionally important ecosystems of salt-pans. Integration of salt-farming by involving stakeholders, such as salt-workers, local villagers, authorities, etc. will not only help in the preservation of salt-pans but also provide job opportunities.

Bhandup salt-pans can be used for fish culture, prawn culture, and fish meal culture. Bhandup salt-pans have a great scope of zooplankton cultivation throughout the salt production period. This paper deals with the conceptualization of live fish meal culture on the shore of one of the heaviest populated cities on the earth. This innovative practice will be able to help hundreds of local people and help in the growing blue economy of the nation.

Thousands of acres of coastal areas in Maharashtra are used for fish farming and prawn culture. The zooplankton is a natural food for all these cultivable fishes and are in very high demand. As per their abundance in the salt-pans and market demands following zooplankton are advised to cultivate in the salt-pans area during the salt production period for benefits of salt farmers as well so they can earn money to some extent.

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