Study of Post Monsoon Water Quality Parameters in Pulicat Lake Ecosystem using Remote sensing and GIS

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Abstract

Pulicat Lake constitutes fragile ecosystem in Coromandal coastal zone in south India and is an important indicator of environmental degradation. It is the nursery and the breeding place for various species of flora and fauna. Physio-chemical parameters like Depth of the Lake, pH, Alkali, Salinity, nutrients including Silicate, Nitrate as well as Phosphate containing the ions Ca, Mg, Na and K are essential for their life growth. These parameters were studies on collecting the water samples in the Lake using the manual boat in Feb 2018 and analyzed using Remote sensing data and GIS. The parameters are plotted in GIS environment using Cartosat 2013 satellite data. Pulicat Lake is delineated with ERDAS 2015 and Processed in ARC GIS 10.3.1. The Contours are generated for distribution of Water Quality Parameters in the study area and layouts are prepared in ARC GIS. The parameters variations are identified because of the input flow of water coming from the rivers and high runoff in rainy seasons.

Keywords: *Pulicat Lake, Water Quality Parameters, Imagery, ERDAS, ARC GIS.*

1. Introduction

Pulicat Lake is home for 168 different species and more than 110 varieties of terrestrial and aquatic birds and small mammals and reptiles [1]. About 15,000 flamingos visit the Lake on their annual migration route. More than 60,000 migrant water birds feed and breed in the northern part of the Lake during winter. About 50,000 People [2] living in 52 villages [3] on the banks of the Lake in the Tamil Nadu side and depend directly and indirectly on the Lake. In the Northern part of the Lake in Andhra Pradesh, more than 15 small villages are identified newly after 2014 Tsunami for fish catching. Durgarajapuram, Pulicat, Sriharikota and Sullurpet are the major cities located on the periphery of the Lake. Three major rivers Kalanji, Arani, Swarnamukhi and small tributaries like Royyala kalava plays a major role in the variations of the water quality Parameters [4][5]. The drainage basin of the Lake, which covers around 4450 km^2 has also have effect.

The Andhra Pradesh government allocated 4700 hectares of land for a marine chemicals and salt manufacturing industries on the fringes of the Lake, where as in Tamil Nadu, a petrochemical complex, power plant and the satellite port in Ennore Creek were major ecological threats. The Lake area shrinkage is due to the siltation and the shallow water area conversion into the mudflats and then drylands in summer in Andhra Pradesh. These dry lands are occupied by the villagers for fishing in the surrounding water body areas. The land use activities of the villagers causing the salinity changes may cause the decrease of the migrating birds in near future. And at the same time, the government of Andhra Pradesh, is making the Coromandal coast as Industrial corridor, which covers the Pulicat Lake. Earlier there were around 50,000 fishermen in the area but due to lack of jobs, thousands of farmers and laborers living in the Lake region started fishing in the Lake. Prawn

farms and an increasing population put additional pressure on the Lake's ecosystem. Overuse of the natural resources and shortage of clean drinking water are inevitable consequences. Over-exploitation, Mismanagement as well as improperly treated industrial effluents containing heavy metals from more than 35 industries which are located in and around the Lake deteriorate the water quality. Siltation is a major problem affecting the Lake. Soil erosion in the catchment area of the three rivulets is causing widespread siltation in the Lake [6]. The water quality parameters, viz, Water depths, pH, Alkality, Salinity, No_2, PO_4, Silica, Ca, Mg, Na, and K, and environmental conditions of the ecosystem influence Lake Sustainability [7].

2. Study Area

Pulicat Lake located on the Coromandal coast, occupying in between two states, viz, Andhra Pradesh and Tamil Nadu Covering an area of about 952.75 Km^2, spreading 88 % (835.30 Km^2) and 12 % (117.45 Km^2) respectively, starting from Durgarajapuram in the north to the Pulicat town in the south. The location of study area is shown in Fig. 1. Geographically it is in between Longitudes 80°00'00" - 80°20'50" E and Latitudes 13°20'40" - 14°00'00" N. The length of the Lake in the study area is around 85 Kms and width is 20 Kms. The Climatical conditions in the entire Lake are pleasant and it maintains a temperature from 10°C to 33°C [8]. The rainfall is heavy in this region ranging from 800 mm to 2400 mm. Continuous strong winds with an average speed of 9 to 16 km/hr are common from the south - west for seven months (Mar - Sep) in a year, giving rise to strong waves in the Lake throughout the day.

Fig. 1. Location of study area.

3. Materials and Methods

The number of water samples collected in Feb 2018 were 30 covering the entire lake starting from the Pulicat village near the bar mouth in the eastern part to the Kalanji River in the western part on using the mechanized boat. The GPS Instrument used for tracking latitudes and Longitudes is Garmin eTrex. The samples were analyzed using the various methods in the laboratory. The depths of the water in the Lake were taken from Fathometer. The sample points along with the longitude and latitude are noted and shown in the Fig. 2. Instruments used for the testing the Water Quality Parameters are pH meter, Nephelometer, Electrical Conductivity meter, Nitrate Nitrogen Comparator for Nitrate test, etc. All the Samples were done pre-treatment (filtering) using the filtering papers. The Chemicals used for the testing are Buffer solution and Barium Chloride for sulphate test, Ammonium molybdate reagent, and stannous chloride reagent for phosphate test, etc. Ca and Mg are determined titrimetrically, Nitrogen, Phosphate and Silicate were estimated spectro-photometrically and potassium were determined by flame photometer. The water parameters are tabulated in the *Table: 1*. The results are mapped with the ERDAS and ARC GIS 10.3.1 softwares to get more clarity of the spread of the water parameters and for analysis. In this process, Cartosat - LISS III image of 2013 is used for Lake demarcation and for contour generation.

4. Results and Discussions

Lake Water Depths

The Lake is a delicate system that requires constant inflow of seawater. But due to the continuous movement of water and the tidal influence, it adversely affected by the sand deposition resulting the reduction of depths from msl. *Figure. 3* show the depths spread throughout the Lake. From this map it is evident that the Lake depths are ranging from 3.0 to 11.0 ft.

Lake Water pH

The reduction in pH values during the Post monsoon was due to the input of fresh water in rainy season from rivers Kalanji, Arani, Swarnamukhi and other small tributaries. The drainage basin of the Lake and the Buckingham canal as a part of the Lake are influencing the pH parameter. The water exchange between the Lake and the Bay of Bengal is mostly takes place in the northern part of the Lake, just above the Satish Dhavan Space Centre and in the North-Western part of the Lake. The water pH values are ranging from 8.1 to 8.9 and are shown in the *Figigure. 4.* From this map it is clear that the southern part as well as the western part of the Lake, the values are high. Where the central part and the northern part are having low in pH values.

Lake Water Alkalinity

The alkalinity ranges from 213 to 298 mg/L. This parameter is also due to the fresh water intrusion by the rivers, rainwater and the groundwater levels increase in the rainy seasons. Due to the precipitation of the $CaCo_3$ in the Lake waters, there is a reduction of alkalinity in the water. This calcium may come out in the summer due to the water evaporation, thereby reducing the alkalinity. In summer there is a much shell mining and processing in the surroundings of the Lake. The water alkalinity values are shown in the *Figure. 5*. From this map it is clear that the western parts of the Lake, values are high compared to the eastern side of the Lake.

Lake water Salinity

Sources of Salinity in Lake water include urban and rural runoff from Industry, sewage, agriculture and storm water. Cleaning of vegetation also causes the raising the levels of salinity due to resultant rise in the water table. The salinity in the Lake ranges from 1.8 $^0/_{00}$ to 6.9 $^0/_{00}$. The lowest salinity values noted are always in the rainy season due to the much fresh water mixing with the Lake water coming from the rivers and the water table rise. The dilution of fresh water in the Lake reduced the concentrations of Ca, Mg, Na and K ions in the post monsoon. Salinity is varying between the low tide and the high tide areas of rivers which flow into the sea. The water salinity values are shown in the *Figure. 6.* From this map it is clear that in the western parts of the Lake, the values are low compared to the South-eastern side of the Lake.

Silicate in Lake Water

Silicate generally has the tendency to get absorbed into the suspended matter and co-precipitate with humus substances and other materials [9]. The silica concentration was very less in the Post Monsoon ranging from 37 to 99 ppm. The silicate values in the Lake water are shown in the *Figure. 7.* From this map it is clear that in the western and southern parts of the Lake, the values are high compared to the northern side of the Lake.

Nitrate and Phosphorous in Lake Water

Freshwater coming from the rivers brings the Nitrates and the Phosphates elements. But, in the Lake water, the quantity is almost negligible. Nitrate is an oxidized form of nitrogen. The high levels of Nitrate levels lead to lower the DO levels in the water, which may disrupt the entire system. Phosphorus does migrate in groundwater, raising concerns that phosphorus containing ground water discharging into the Lakes may accerate the eutrophication of the Lake. The Nitrate values are ranging from 0.1 to 0.2 ppm and the phosphate values are ranging from 0.6 to 0.7 ppm, which is very low in the Pulicat Lake. Phosphate is not toxic to plants and the animals, but it is a plant nutrient, which stimulates the growth of aquatic weeds and algae. This may cause Lakes to become clogged and overrun with the bushes and plants.

Calcium in Lake Water

Calcium and Magnesium are the important elements in metabolism at the organism and the system levels are well known. While calcium is an integral constituent of cell wall material, Magnesium is an important component of the Chlorophyll molecule [10]. Calcium is the major element that is abundant in the Lake in different forms, viz, shells. Due to this, the shell mining is the major activity in the Lake regularly. The Calcium values are ranging from 17 to 100 ppm. *Figure. 8* shows that the western and south western side of the Lake is abundant in calcium. Due to this, southern side of the Lake is having the shell mining and shell processing industries.

Magnesium in Lake Water

Magnesium is another metal which is available in water ranging from 85 to 192 ppm. *Figure. 9* shows that the southern part as well as the northwestern part is having much in range compared to the other parts of the Lake.

Sodium in Lake Water

Sodium ion is common in water. Sea water intrusion, mineral deposits, sewage effluents etc. contributes sodium to Lake water. Sodium is rich in the Lake water due to continuous inflow of sea water. It is a regular phenomena from three different places viz, Pulicat town, Samantyala kuppam (Nawabpet beach) as well as the Tupilipalem. *Figure. 10* shows that the Sodium range is from 380 to 720 ppm. The spread of the Sodium is mostly in the southern side as well as in the eastern side of the Lake.

Potassium in Lake Water

Potassium ion concentrations are very small in quantity in Lake water. The excessive amounts may result laxative effect. This Potassium element is entering into the Lake from fresh input waters of the rivers. The values are ranging from 36 to 89 ppm. The distribution of the Potassium concentrations throughout the Lake is shown in the *Figure. 11*. The value is high near the inflow river water compared to the other parts of the Lake.

Conclusions

The change of Physico chemical parameters are resulting the deterioration of Lake water very slowly. It is in need of the appropriate management policies and strategies to be implemented by the state governments. Due to the pleasant weather conditions, the birds

are migrating seasonally, as the lake is providing the feeding and breeding place to them. This is the good sign for the presence of naturality of the Lake. The pH values are within the limits, even though fewer industries are located along the fringes of the lake. The alkalinity, Salinity, and other parameters were got effected by the land use activities of the public in and around the Lake. These parameters are within the limits for survival of birds, metabolism as well as the physiology of the aquatic organisms. Due to the siltation, the depth and the size of the lake are reducing periodically. The Aquaculture is increasing in the northern side of the lake as there is much brackish water. Due to the abundance of Calcium present in the lake, the Shell mining and Shell processing Industries are the major Industries in the western and southern parts of the lake. The Lake is not much affected by the sea water due to presence of sand bars and shoals in the eastern side of the Lake. The exchange of fresh water and the sea water is a regular phenomenon in the Lake. As the Government of Andhra Pradesh is planning, Industrial Corridor along the Coromandal coast, The Lake should be given exclusions upto a minimum of 6 Kms as a buffer zone for the implementation of Industrial Corridor.

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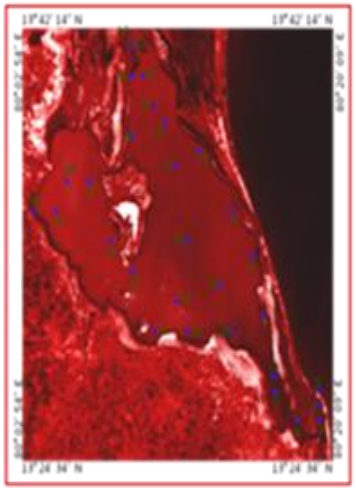
Table.1 – Analytical Results of Pulicat Lake Water Samples Collected during the Post monsoon (Feb.2018)

Sample Number	Longitude (E)	Latitude (N)	Depth (Feet)	pH	Alk (mg/L)	Sal ($^0/_{00}$)	No_2 (ppm)	Po_4 (ppm)	Si (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)
1	80° 19’ 12”	13° 26’ 60”	2.5	8.3	243	6.0	0.1	0.7	68	98	165	608	52
2	80° 19’ 48”	13° 27’ 36”	9.0	8.8	260	6.9	0.1	0.6	74	102	178	762	54
3	80° 19’ 12”	13° 26’ 24”	9.0	8.6	242	6.8	0.1	0.6	68	96	166	610	60
4	80° 17’ 60”	13° 26’ 24”	9.1	8.5	230	6.9	0.1	0.7	69	97	170	610	50
5	80° 16’ 48”	13° 27’ 36”	8.4	8.2	240	5.8	0.1	0.6	44	90	110	580	48
6	80° 16’ 48”	13° 28’ 12”	8.3	8.1	238	5.9	0.1	0.7	48	92	119	590	46
7	80° 16’ 12”	13° 30’ 36”	8.2	8.2	239	5.9	0.1	0.6	52	99	132	610	36
8	80° 15’ 36”	13° 33’ 00”	8.0	8.3	242	5.9	0.2	0.7	62	100	130	592	42
9	80° 14’ 24”	13° 34’ 48”	9.9	8.4	241	5.9	0.1	0.7	61	92	112	560	38
10	80° 12’ 36”	13° 37’ 12”	9.8	8.1	238	4.6	0.1	0.6	48	85	92	582	42
11	80° 08’ 45”	13° 40’ 48”	9.6	8.5	259	4.8	0.1	0.6	46	76	140	569	58
12	80° 10’ 48”	13° 38’ 24”	10.3	8.0	255	4.6	0.1	0.6	52	96	85	495	46
13	80° 09’ 39”	13° 40’ 12”	10.6	8.2	240	4.6	0.1	0.7	58	67	112	446	51
14	80° 09’ 00”	13° 41’ 24”	10.5	8.5	213	3.2	0.1	0.6	38	17	96	532	52
15	80° 09’ 00”	13° 40’ 12”	8.4	8.6	250	4.8	0.2	0.7	42	82	123	601	62
16	80° 10’ 12”	13° 39’ 00”	9.0	8.4	263	4.3	0.1	0.6	52	68	142	553	57
17	80° 09’ 00”	13° 37’ 48”	9.0	8.1	282	4.8	0.1	0.6	62	71	131	559	43
18	80° 11’ 24”	13° 36’ 36”	10.2	8.3	291	5.2	0.1	0.7	60	73	146	582	56
19	80° 12’ 00”	13° 33’ 36”	10.8	8.4	299	4.3	0.1	0.6	58	69	157	560	43
20	80° 19’ 48”	13° 31’ 48”	10.3	8.4	276	4.2	0.1	0.6	37	65	149	550	41
21	80° 14’ 24”	13° 30’ 00”	10.6	8.3	289	4.1	0.1	0.7	54	83	155	549	52
22	80° 12’ 00”	13° 30’ 00”	10.0	8.2	299	4.0	0.1	0.6	55	93	168	589	55
23	80° 11’ 24”	13° 31’ 12”	8.4	8.0	256	4.8	0.1	0.6	48	73	173	544	89
24	80° 10’ 12”	13° 30’ 00”	7.6	8.9	298	4.9	0.2	0.7	58	77	162	552	54
25	80° 09’ 00”	13° 32’ 24”	7.6	8.3	229	3.8	0.1	0.6	57	98	180	538	64
26	80° 07’ 48”	13° 33’ 36”	6.5	8.2	264	3.9	0.1	0.7	55	76	192	588	68
27	80° 06’ 36”	13° 35’ 60”	7.3	8.1	298	3.9	0.1	0.7	62	82	168	538	68
28	80° 05’ 24”	13° 35’ 60”	8.3	8.0	288	2.8	0.1	0.6	98	99	122	452	70
29	80° 04’ 48”	13° 34’ 48”	8.0	8.1	280	2.6	0.2	0.6	96	99	120	380	88
30	80° 04’ 48”	13° 34’ 48”	8.5	8.2	292	1.8	0.1	0.6	99	93	132	334	83



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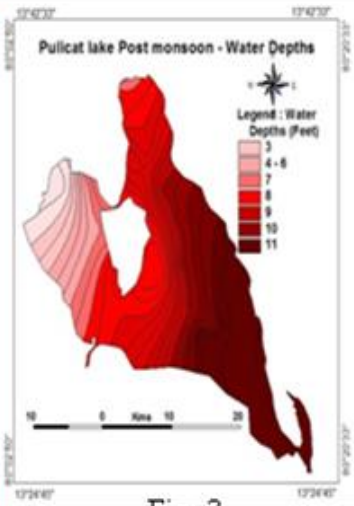

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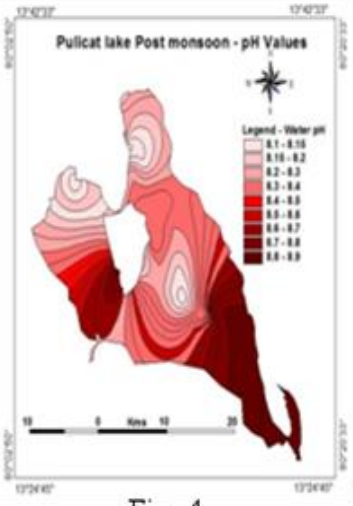

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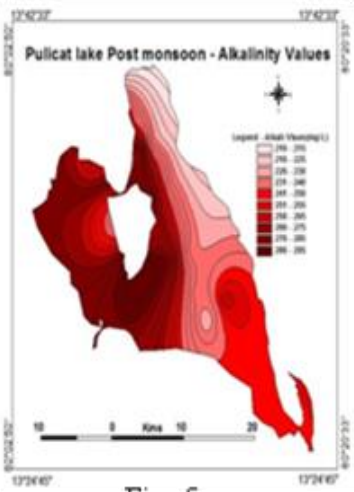

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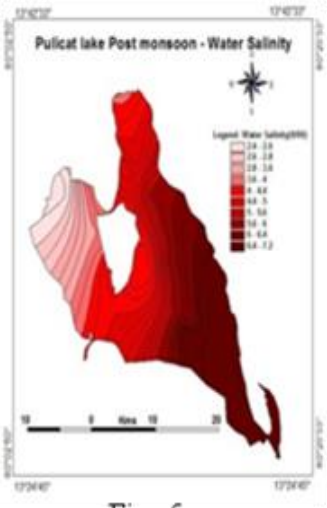

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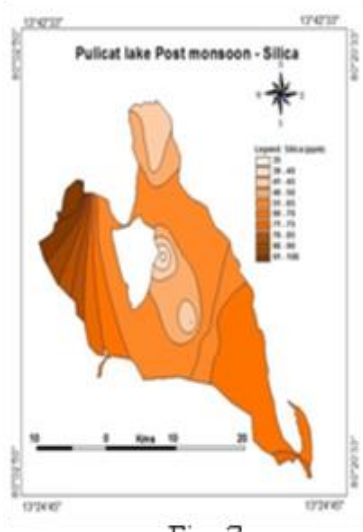

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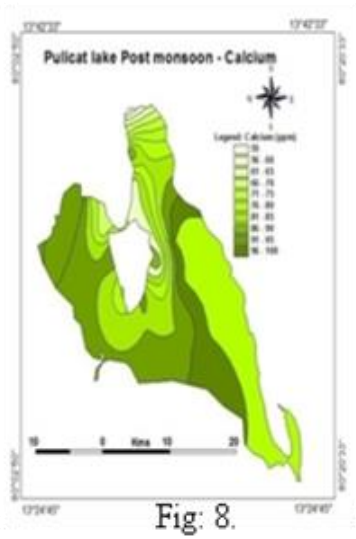

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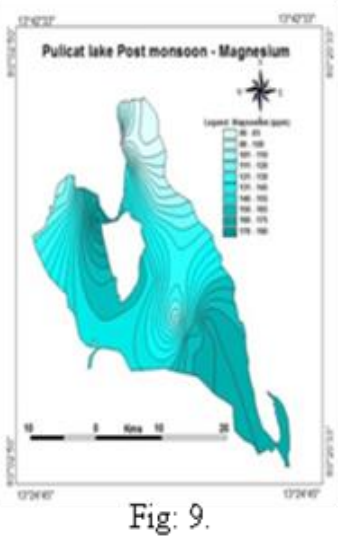

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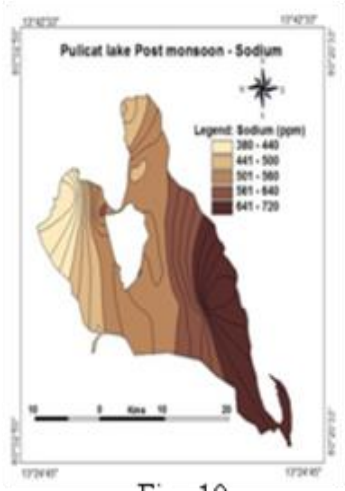

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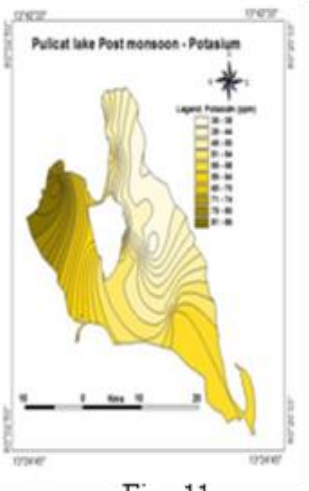

Fig: 11.

Figures. 3 to 11. - Spatial Results of Pulicat Lake Water Quality Parameters during the Post monsoon (Feb.2018)