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AQUATIC INSIGHTS: HYDROBIOLOGY OF BANDRA SEA LINK, KHAR DANDA AND JUHU BEACH MARINE ECOSYSTEM

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Abstract: Out of the total water present on Earth, only 2% is fresh water; whereas rest of the 98% is marine water. Thus, the marine ecosystem becomes the richest and prosperous ecosystem of all. Maintaining a balance between the environment with that of the organisms living in and around it becomes very crucial. This blessing of nature is depleting day by day due to various anthropogenic activities which also affect the hydrobiology of the wetlands and in turn the marine biodiversity. A large number of the waste generated through anthropogenic activities find their way into the polluted coastal waters in the area under study. The present work deals with the "Comparative aspect of hydrobiology of Bandra Sea link coast (site A), Khar Danda (site B) and Juhu Beach (site C)". Hydrological parameters like colour, odour, salinity, temperature, pH, CO2, DO, BOD, COD, Hardness, along with nutrient like Phosphates from three selected sites was carried out for a year. Standard method was used for estimation of various parameters. Dumping of wastes, domestic sewage and industrial effluents has affected the hydrobiology of this coastal water.

Keywords: Marine ecosystem, anthropogenic, hydrobiology, Bandra sea link, Khar Danda, Juhu beach

Introduction: Water pollution is defined as, 'the contamination of the waters by foreign matter such as microorganisms, chemicals, industrial wastes, sewage or other wastes. Such matters, deteriorates the quality of the water and renders it unfit for its intended use' [1]. The main area of dumping all these substances has always been the rivers and estuaries.

In other words, "We are the trustees of the environment for future generations and our approach to development must reflect this." (IUCN) [2]. Estuaries, creeks, lagoons, coral reefs etc. are together known as coastal wetlands. These habitats in the world being of great ecological and economic significance, global efforts are being made to manage these resources on a sustainable basis [3].

Mumbai city has a total area of 440 square kilometres (170 square miles). Mumbai has a 26-kilometer-long shoreline on its western side. Large and tiny waterways crisscross the coastline. Mumbai is the industrial heart of everything from textiles to petrochemicals, domestic, agricultural, and industrial activities all have an influence on aquatic ecosystems. Half of Mumbai's citizens live in slums or are homeless, with no access to sewage or sanitation services, and utilize the city's coastline region as a natural toilet, resulting in massive amounts of sewage being dumped straight into the Arabian Sea. The coastal water in and around Mumbai is polluted as a consequence of a large volume of industrial and household wastewater input. In Mumbai's coastal waters, a general tendency of nutrient elevation has been observed.

The Bandra-Worli Sea Link **(site A),** is a 5.6 km long, 8-lane wide cable-stayed bridge that links Bandra in the Western Suburbs of Mumbai with Worli in South Mumbai. **Khar Danda (site B),** which is derived from the term Khara, got its name from the salt pans that residents used to produce salt along the Khar Danda seashore a couple of centuries ago. Khar-Danda is fishing town where Fish farming is a common activity, and other human activities such as body cremation, residential sewage, and feces discharge have had a significant impact on the environment of the beach and the sea. **Juhu beach (site C),** is the most popular beach in Mumbai. Spread over five to six Kilometers long

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seashore along the western coastline. The beach is frequently visited by tourists. The beach is generally crowded in the evening as the visitors usually come at these hours for fresh air and pleasure strolling.

The current research examines the influence of humans on the coastal ecology. Various ecologists have documented pollution of water bodies, and pollutants have an impact on aquatic ecosystems as well as the human food chain owing to bioaccumulation. Although there is little doubt that pollution may have an impact on aquatic creatures in the laboratory and be accountable for population declines, [4, 5].

However, it is well recognized that water contamination, particularly in coastal waters, has been a consequence of urbanization and industry in recent decades [6]. As a consequence, several aquatic species have become extinct or scarce in certain large water bodies [7]. In the last 20 years, there has been a growing worry that pollution may have an impact on the health of fish and other aquatic animals [8]. In general, diseases in fish and other aquatic animals are localized, but scientists are concerned that certain cancers, particularly liver tumours, in demersal fish inhabiting polluted estuaries and coastal waters are linked to the release of potentially harmful substances into the aquatic environment, such as pesticides, heavy metals, and hydrocarbons. When huge amounts of these pollutants are discharged, there may be an immediate effect, such as large-scale abrupt mortalities of aquatic animals, such as fish deaths caused by agricultural pesticide pollution of streams [9]. Lower discharge levels might lead to a buildup of contaminants in aquatic creatures. Immune suppression, lower metabolism, and damage to gills and epithelia are some of the long-term effects that might occur after contaminants have passed through the ecosystem. In normal conditions, a number of things may have an impact on water quality. Changes in water parameters are caused by a variety of reasons, including: Organic pollutants produced by household wastes, pollutants originating in run-off water, pollution of nutrients and the influence of temperature on the seasons.

Research Methodology: For studying the effect of anthropogenic activities, the study area was divided into three different sites. The sampling sites were judiciously selected in a manner that showed variation in different parameters studied. For sake of convenience, these sites were given names as: Site 'A'- Bandra Sea link coast which is situated near Bandra reclamation. This site also receives sewage water from the city. Site 'B'- This site is situated at Khar Danda. Fishing is carried out at this site. A fish market is also present close to this site. Site 'C'- Juhu beach site, which is the longest beach of Mumbai. This beach is famous for its street food stalls, and white marble ISCKON temple. Be it any time of the year or any day of week, Juhu beach is crowded by tourist and locals alike.

The duration of the sample collection was from –July 2014 to February 2015 which comprised of monsoon months (July, August and September), winter months (October, November, December), and summer months (January, February) in order to study the seasonal variation. The samples were tested for various physical and chemical parameters like Colour, Odour Temperature, DO, CO2, pH, Salinity, Total Hardness, Phosphates, COD and BOD of water were measured using conventional APHA procedures [10].

Results and Discussions: Table 1: Monsoon period (July to September)

Hydrological Parameters	Bandra Sea Link Site 'A'	Khardanda Site 'B'	Juhu beach Site 'C'
COLOUR	Grey to blackish	Greenish	Light Brown to brown
ODOUR	Fishy, H_2S	Fishy	Fishy
TEMP ^oC	Min-29 Max -32 Mean-30.66	Min -29 Max -33 Mean -30.6	Min -29 Max -32 Mean -30.6
SALINITY $^o/_{oo}$	Min -12 Max -27 Mean -18	Min -13 Max -26 Mean 18-	Min -20 Max -35 Mean -25.33
PH	Min -6.6 Max -7.4 Mean -6.93	Min -6.2 Max -7.8 Mean -6.83	Min -6.3 Max -7.5 Mean -6.9
HARDNESS mg of Ca/l	Min -2805 Max -4508	Min -2605 Max -4986	Min -2809 Max -4589

	Mean -3473.6	Mean -3385.3	Mean -3536
DO mg/L	Min -2.98 Max -3.89 Mean -3.48	Min -2.42 Max -2.92 Mean -2.65	Min -2.55 Max -3.87 Mean -3.14
CO_2mg/L	Min -8.71 Max -12.43 Mean -10.57	Min-11.03 Max -12.83 Mean -12.01	Min -9.01 Max -12.39 Mean -10.66
COD mg/L	Min -149.2 Max -187 Mean -163.06	Min -168.4 Max -308.1 Mean -230.50	Min -143.6 Max -182.5 Mean -162.36
BOD mg/L	Min -4.95 Max -6.81 Mean -5.79	Min -6.12 Max -7.56 Mean -6.77	Min -4.91 Max -6.91 Mean -5.85
PO_4 µgatm/l	Min -120 Max -179 Mean -146.66	Min -168 Max -220 Mean -187.66	Min -123 Max -176 Mean -147.33

Table 2: Winter (October to December)

Hydrological Parameters	**Bandra Sea Link Site 'A'**	**Khardanda Site 'B'**	**Juhu beach Site 'C'**
COLOUR	Grey to dark blackish	Greenish clear	Light Brown to brown
ODOUR	Fishy H_2S	Fishy	Fishy
TEMP ^oC	Min-22 Max -23 Mean-22.5	Min -26 Max -27 Mean -26.5	Min -23 Max -27 Mean -24.66
SALINITY $^o/_{oo}$	Min -18 Max -23 Mean -20	Min -17 Max -24 Mean -20.33	Min -19 Max -31 Mean -23.33
PH	Min -6.6 Max -7.8 Mean -7.05	Min -6.6 Max -7.2 Mean -6.86	Min -6.3 Max -7.9 Mean -7.03
HARDNESS mg of Ca/l	Min -2018 Max -4998 Mean -3041.3	Min -2619 Max -3518 Mean -2885.3	Min -2013 Max -4973 Mean -3032
DO mg/L	Min -2.20 Max -3.45 Mean -2.88	Min -1.24 Max -2.20 Mean -1.65	Min -2.23 Max -3.49 Mean -2.90
CO_2mg/L	Min -12.01 Max -16.67 Mean -14.65	Min -11.23 Max -11.92 Mean -11.64	Min -12.21 Max -15.21 Mean -13.67
COD mg/L	Min -155 Max -175 Mean -162.33	Min -168.4 Max -308.1 Mean -12.01	Min -150.4 Max -173 Mean -159.90
BOD mg/L	Min -5.27 Max -6.01 Mean -5.73	Min -5.51 Max -7.98 Mean -6.54	Min -5.37 Max -6.2 Mean -5.85
PO_4 µgatm/l	Min -152 Max -167 Mean -158.33	Min -177 Max -209 Mean -192	Min -152 Max -169 Mean -158.6

Table 3: Summer (January to February)

HYDROLOGICAL PARAMETERS	Bandra Sea Link Site 'A'	Khardanda Site 'B'	Juhu beach Site 'C'
COLOUR	Blackish	Greenish turbid	Brownish
ODOUR	Fishy H_2S	Fishy	Fishy
TEMP ^oC	Min-26 Max -32 Mean-28.66	Min -28 Max -34 Mean -30.33	Min -27 Max -33 Mean -29.66
SALINITY $^o/_{oo}$	Min -17 Max -21 Mean -19	Min -19 Max -21 Mean -20	Min -23 Max -25 Mean -24
PH	Min -6.3 Max -6.5 Mean -6.4	Min -6.3 Max -6.6 Mean -6.45	Min -6.1 Max -6.6 Mean -6.35
HARDNESS mg of Ca/l	Min -2578 Max -2916 Mean -2747	Min -2717 Max -2695 Mean -2706	Min -2532 Max -2913 Mean -2722
DO mg/L	Min -2.18 Max -2.27 Mean -2.22	Min -1.32 Max -1.52 Mean -1.42	Min -2.18 Max -2.27 Mean -2.22
CO_2mg/L	Min -16.23 Max -16.53 Mean -16.38	Min -11.51 Max -11.71 Mean -11.61	Min -15.96 Max -16.47 Mean -16.21
COD mg/L	Min -163 Max -168 Mean -165.52	Min -229.2 Max -232.48 Mean -230.84	Min -162.45 Max -169.87 Mean -166.6
BOD mg/L	Min -4.14 Max -5.21 Mean -4.67	Min -5.88 Max -5.91 Mean -5.89	Min -4.83 Max -5.09 Mean -4.96
PO_4 µgatm/l	Min -162 Max -168 Mean -165	Min -181 Max -191 Mean -186	Min -143 Max -148 Mean -145.5

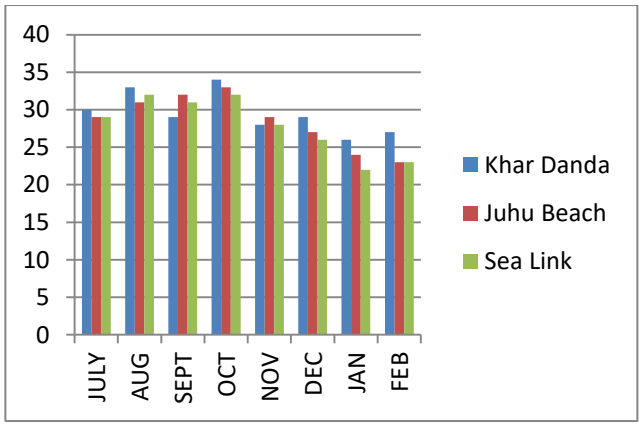

Fig No 1.Temperature in Celsius

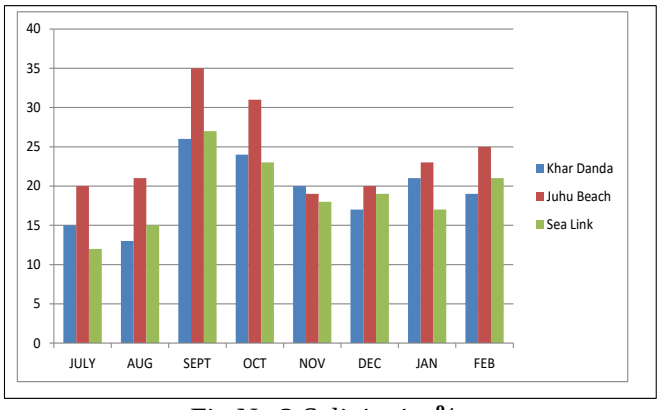

Fig No 2.Salinity in $^o/_{oo}$

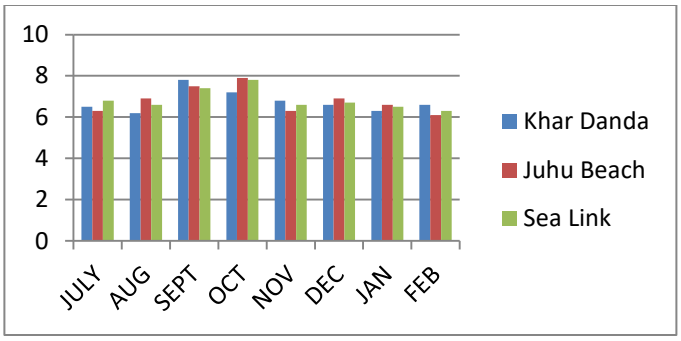

Fig No 3. pH

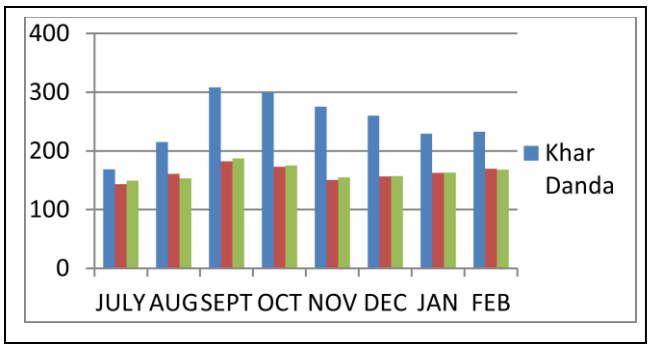

Fig No 7. Chemical Oxygen Demand in mg/l

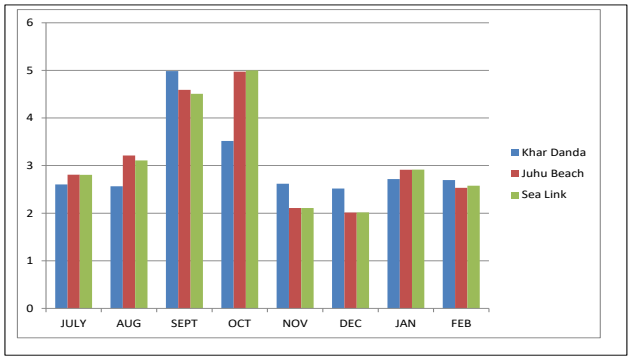

Fig No 4. Total Hardness Ca gm/l

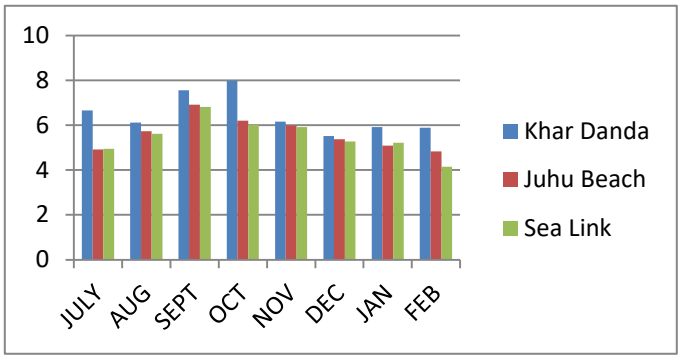

Fig No 8. Biological Oxygen Demand in mg/l

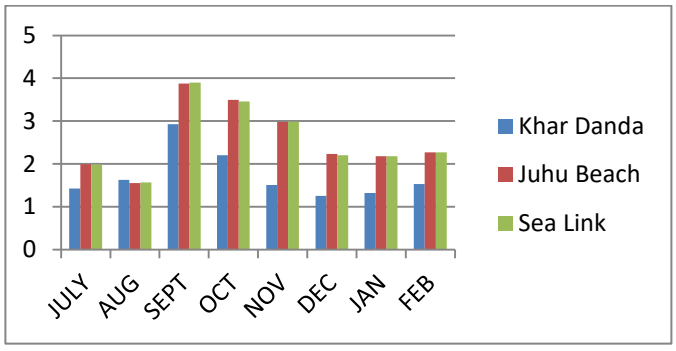

Fig No 5. Dissolved Oxygen in mg/l

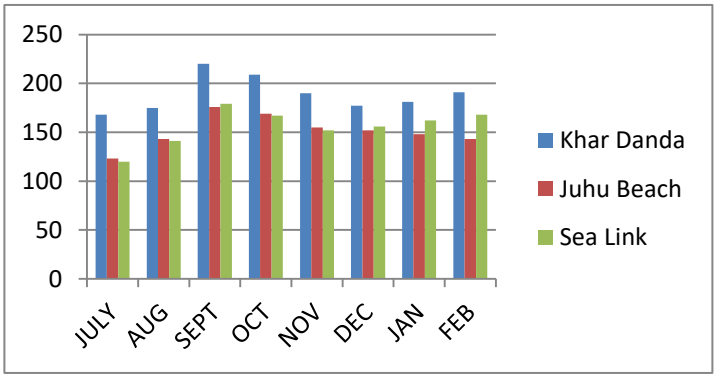

Fig No 9. Phosphate-Phosphorous content in ug atom/l

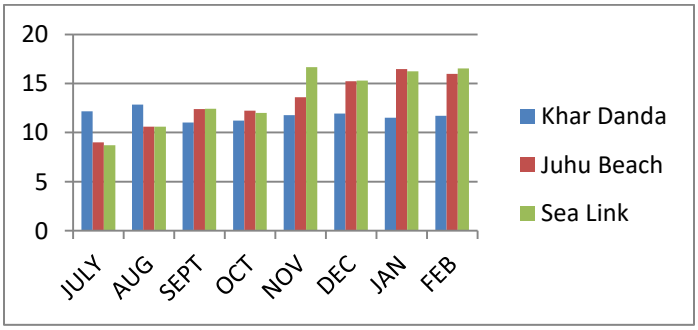

Fig No 6. CO_2 (Carbon dioxide) in mg/l

Colour & Odour: In the present study it was seen that, the site 'A' (Bandra Sea link) water was black in colour during most of the months, more turbid and had a strong H_2S like smell. At site 'B' (Khar Danda), water appeared greenish brown, and a fishy odour prevailed especially during pre-monsoon period. At site'C' (Juhu beach) the colour ranged from brown to dark brown and again pale brown in the post winter, with fishy odor prevailing throughout the study period.

Temperature: The temperatures of all the three sites ie site A, B, C were from 22-31^{o}C Overall study clearly

indicated that, the variation in temperature was season dependent. It was highest during the pre-monsoon period and least during the post monsoon period. Seasonal variation is associated with the quantities of rainfall and climatic change [11].

Salinity: Salinity was least during the monsoon period except at site C. Average salinity was around 20-22$^{o}/_{oo}$. It is evident from the observation that the salinity showed higher and highest values in the post monsoon (winter) and pre-monsoon (summer) period respectively. Highest values of salinity in the summer season could be because of the highest temperature in this season which in turn could have led to increased evaporation of water and hence maximum concentration of salts in waters.

pH: In the present study, there was significant variation in all the three seasons. pH value was seen to be decreasing during monsoon, for all the sites, whereas, it showed higher readings in post-monsoon and the highest readings during pre-monsoon season. The seasonal variation could be attributed to dilution of sea water during monsoon season, whereas, increase on alkalinity could be because of evaporation of water during other seasons as well as addition of detergents present in domestic sewage.

Total Hardness: From the present study, highest value recorded for all the three sites during monsoon was 3473.6mg/l, 3385.33mg/l, and 3536 mg/l respectively for site 'A','B', & 'C' respectively. It tends to decrease to least during summer period. This could be due to seasonal variations and release of pollutants through sewage imparting hardness to the waters.

Dissolved Oxygen (DO): There was significant seasonal variation recorded in the present study, which could be the effect of evaporation of water and concomitant depletion in Oxygen
in summer period. This could be possibly because of the extreme temperatures, accompanying evaporation of water & because of increasing load of domestic sewage. In monsoon the level of DO, increased (with average 3.48mg/l, 2.65mg/l, & 3.14mg/l), & post-monsoon period, the levels were intermediate (average 2.47mg/l). This could be due to inflow of fresh water & heavy rainfall may have increased phytoplankton population, thus adding to Oxygen content of the sea water because of photosynthesis [12, 13]. Study on Gorai creek by Reza M,[14] also showed similar conditions. The least DO value at site 'B' indicating most polluted region among the three sites.

COD & BOD: Highest COD values recorded at site 'B' throughout the study period with highest during post-monsoon was 278.06mg/l and the decreased during monsoon and pre monsoon with an average of 230.5mg/l. Overall study indicated the BOD value was on higher side for site 'B' as compared to other two sites. Waste with high values of COD and or BOD can result in de-oxygenation of water and sediment. The decomposition of organic waste can release large amount of nutrients which can lead to undesirable algal blooms which is often followed by de-oxygenation [15].

Phosphates-Phosphorous: Excess quantities of Phosphates indicate pollution. Though it poses problems in surface waters, its presence is necessary for biological degradation of wastewater. Inorganic Phosphates like orthophosphates are of environmental importance [16]. Mixing of sewage can add to Phosphates and lead to eutrophication. Therefore, its estimation becomes very important for hydrobiology purpose. The comparative studies shows that the highest phosphate value during monsoon period was at site B, increased levels of nutrients like PO_4-P, NO_3-N, may be due to domestic sewage which could lead to eutrophication and concomitant damage to ecosystem.

Conclusion: Coastal zones occupy 18% of the surface of the globe where around a quarter of global primary productivity occurs and supply approximately 90% of world fish catch. 60% of the population lives here. Terrestrial and marine processes dominate the coastal zones creating forms produced by erosion like wave cut platforms, sea stacks and sea caves and those produced by deposition like, beaches, deltas, mudflats, and pits. Estuaries and creeks, often colonized by mangroves are common along a number of tropical coasts. The geomorphic processes at work are determined by a number of environmental factors-geological, climatologically, biotic, tidal and oceanic factors like salinity. In the present study, it was observed that, anthropogenic activities like release of sewage water, dumping of garbage such as papers, plastics, thermocols, etc have started affecting hydrobiology and also biodiversity of study area. Hence decline in the health of ecosystem.

Site 'B' Khar Danda beach was the most polluted area as this site is visited by many tourists as well locals and also sewage water is let out directly into the sea water followed, by Site 'C' Juhu beach and least at Site' A' Bandra sea link. At the site B i.e Khar Danda which is visited by the local people staying there as well as visitor

from the vicinity. This also corresponds to high values of COD, BOD, Phosphate phosphorus, hardness and slightly acidic condition throughout the study period at this site B.

Some of the very important findings in the present study are:

- At Khar Danda, greenish coloured water with algal blooms, indicating eutrophication which in turn could have affected the circulation of water, light penetration and thus stagnation of water. High PO_4-P at this site B followed by site A was recorded. At site A water color was blackish.
- H_2S like stench of water, especially at site A, indicates the excessive load of wastewater and resultant stagnation of water, denoting failure of self-purification of water.
- Depletion of DO content, sometimes as low as 1.42mg/l at site 'B' during the pre-monsoon season. High values of COD and BOD indicating pollution due to mixing of domestic sewage especially at site 'B'.
- A high amount of hardness, which could be due to the high salinity and also due to salts of various elements released through the sewage water, which may be responsible for affecting aquatic animals.
- Increased levels of nutrients like Phosphate-Phosphorus, may be due domestic sewage could lead to eutrophication and the concomitant damage to the ecosystem.
- Temperature on an average was around 30-31^{o}C during the monsoon at all the three sites which could be attributed to climatic change during this period. The monsoon in fact commenced very late and lasted only for a month.
- Khar Danda was most affected site followed by Juhu Beach and Bandra Sea link respectively.

Suggested Remedial Measures:

- Reduce pollutants at their source, thereby reducing pollutants loads on the coastal waters.
- Ensuring effective application of safeguard policies and environmental assessments for development projects.
- Maximizing involvement of local communities and stakeholders, and a commitment to long-term engagement, are keys to success.

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