# Assessment of seasonal variation in physicochemical characteristics of coastal waters of Palghar taluka, northwest coast -Maharashtra.

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**Abstract:-**Seasonal variations in physicochemical parametersof coastal waters in present study were carried along four different locations along Palghar taluka, northwest coast of Maharashtra for a period from November 2019-October 2020.In all seasons BOD levels were found to be beyond the permissible limits(< 3mg/L)ranging from 4.1- 5.56 mg/L and 3.38 - 5.53mg/L at Navapur coast and Dandi creek respectively. All the physicochemical parameters were found to vary least during all seasons at Kelwa coast in comparison to the other sites. Levels of nutrients DO,BOD,turbidity and pH has shown considerable variation in coastal waters both spatially and temporally at anthropogenically exposed sites like Navapur coast and Dandi creek Results showed monsoon season in comparison to non monsoon seasons recorded elevated levels of inorganic nutrients *viz*, nitrite, nitrate, ammonia and phosphate at all sites. The levels of DO,BOD ,pH, and turbidity was found to be not in compliance with CPCB standards at Navapur and Dandi sites of Palghar .

**Key words**:- Seasonal variation, physicochemical, Palghar taluka, inorganic nutrients

**Introduction:-**Oceans being one of the largest ecosystem,have acted as epicenters for exercisingmanymanmade activities in industries,aquaculture and recreation(Gokul.et.al,2019).Owing to its economical importance,source of livelihood and inherent assimilative capacity, coastal regions have seen tremendous rise in population.Approximately one half of world population resides in coastal areas(Sharpe M.,2005).Coastline of Maharashtra which accounts for ~10% of total Indian coastline is a representation of the same.Several studies along different transect of coastal region of Maharashtra has been carried out indicating deteriorating condition prevailing in it. Ingole and Kadam,2003 reported land based runoff leading to reduced saturation of oxygen in water, elevated BOD, phosphate and ammonia levels in many beaches in Mumbai.Gupta et al., 2013 ascribed organic,industrial and nitrogenous nutrient pollution majorly for coastal pollution in Maharashtra. Singare et al,2011 pointed out anthropogenic pressures along Vasai creek altered the physicochemical attributes of sediment to a level that is detrimental for the life forms dwelling in it.Studying the physical facet of an ecosystem highlights the distribution of potential contaminants where as chemical aspect points out the abundance and its form of existence in both living and non living forms of ecosystem.Physicochemical characteristics acts as one of the major influencing factor for aquatic organisms in marine environment and is found to show spatio- temporal variation.It is thus important to monitor the annual cycle of physicochemical characteristics of the water body to assess its quality.The coastal region of Palghar taluka is located 87km north to Mumbai region and hosts the largest industrial town of Tarapur, a major fishing village and port at Satpati and many recreational beaches with Kelwa beach being the most popular.The present study aims at investigating the seasonal variation in physicochemical parameters in coastal water of regions exposed to different appalling conditions.

**Materials and Methods:**

**Study area:-**The study area is located in north west region of Maharashtra.Thephysico chemical parameters in the coastal water at 4 different location along the Palghar coast at Kelwa beach (19°36'39.6"N 72°43'46.8"E),at Navapur coast (19°47'14.1"N 72°40'54.2"E),at Dandi creek (19°47'59.8"N 72°41'19.0"E) and at Satpati coast (19°43'47.0"N 72°41'47.6"E).Kelwa beach is a stretch of 8 km,an increasingly popular recreational beach visited by tourist and locals during weekends.The Navapur coast harbours a submarine outfall which is used for disposal of 25MLD of treated combined domestic and industrial effluent.But from past decade the manifold increase in the effluent generated due to rapid industrialization and urbanization in and around vicinity of Boisar is estimated to be around ~3-4times (NIO,2018).Combined increase in domestic and industrial effluent increases the risk of deterioration experienced by the coast .Dandi creek extends from Dandi village and flows in westward direction towards Arabian sea and finally opens into the Navapur coast.It is a 10 km long creek with very narrow mouth region and towards the upper stretch receives freshwater from tributaries of Surya river.Large volume of partially treated effluent and untreated domestic sewage from nearly by settlements find their way into this creek.Satpati coast is a major fishing village located 10km from Palghar.It is well known for its export quality prawns and pomfret.The port harbours both mechanised and non mechanised boats and is largely used for sorting of fish catch for storage,local market and export. Coast harbours dense human settlement close to the coast as fishing is the major livelihood.

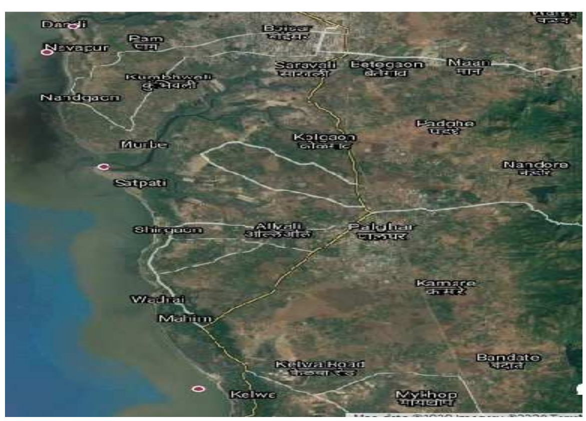


**Fig.1:** Study area showing four study sites at Dandi creek, Navapur coast, Satpati coast and Kelwa coast

**Sampling:-**One litre of nearshore surface water samples were collected from 4 sites viz at Kelwa coast,Navapur coast,Dandi creek and Satpati coast in triplicates in polyethylene bottles pre rinsed with 1N HCl .The sample were collected on monthly basis from November 2019 to October 2020.Collected samples were kept in ice box and brought to laboratory within 6 hrs of sampling.Samples were assessed for physical properties like Temperature and Turbidity and chemical properties like pH, DO, BOD,Nitrite -nitrogen,nitrate-nitrogen, Phosphate -phosphorus, and sulphates as per standard procedures in APHA(1995) and Ammonia by direct nesselerisation method (Aery N.C., 2010 ).The dissolved oxygen was fixed at the site during water collection in BOD bottles.

**Results and Discussion:**

**Temperature:-**Temperature is an important environmental factor in coastal environment affecting the physical and chemical parameters in coastal waters (Bhadja and Kundu, 2012).Surface water temperature is known to alter the metabolic mechanism in the underlying aquatic life forms present in it and thus play a detrimental role in species composition of the community surviving in it (Dupuis and Hann, 2009).In the present study the mean surface water temperature varied from 23.6°C – 30.7°C. The minimum temperature of 21.1°C was recorded at Dandi creek in February 2020 and maximum of 32.1°C was recorded at Navapur coast in May 2020.The temperature was found to increase from postmonsoon to premonsoon(Fig .2) Highest temperature was recorded during premonsoon at all sites could be attributed to higher intensity of insolation and coupled evaporation which occurs during premonsoon() and drop in temperature during post monsoon could be due to strong land sea breeze, tidal cycle, rainfall accompanied by precipitation experienced during the period (Sankpal et al ,2014; Vanmali, H.S. 2018).

**pH:-**pH values in aquatic environment in the range of 5 - 9 are considered to be non toxic to the aquatic fishes but many chemical compounds are found to undergo conversion into toxic forms at this pH (Andrade et al,2011, Llyod ,1960 ).any further increase in acidity or alkalinity could be more thus more detrimental to the life forms in the aquatic environment. The mean pH at the study site was found to vary from 7.08 – 8.04 as shown in Fig.3.The minimum pH was recorded at Dandi creek in April 2020 and maximum pH of 8.12 was recorded in April 2020 at Satpati coast. The pH was found to be lowest during monsoon but within CPCB standards for SW-II (7.5-8.2)at all sites in comparison to non monsoon months except at Dandi creek.Between sites at Dandi creek the pH was found to be lower than the permissible limits during non monsoon months which may be due to the resultant effect of industrial effluent released in the creek and subsequent oxidation of organic matter by the microbes (Zingde and Govindan, 1997) in the present study. Similar low pH values were also reported in Karanja creek and in regions of Vasai creek receiving untreated effluents from the industries (Pawar and Kulkarni,2007 ;Mehta and Amin,2008) . The reported pH values at Dandi creek was found to be lower than the earlier study at Dandi creek by NIO during November 2015 – May 2016.

**Dissolved Oxygen:-**In the present study mean dissolved oxygen levels were found to vary from 4.1 mg/L to 7.55 mg/L. Table.1 shows the dissolved oxygen level recorded to be highest during monsoon at all sites. The higher DO levels during postmonsoon and monsoon could be due to drop in temperature, salinity and turbulent nature resulting in vertical mixing of water due to windy monsoon conditions.(Balakrishnan et al,2017). As a natural phenomenon increase in temperature and salinity reduces the solubility of oxygen, this was reflected in the levels of DO during the premonsoon at all the study sites when it was found to be least in coastal waters Between stations the mean DO levels was observed to be lower at Dandi creek throughout the year irrespective of the seasons in comparison to other sites indicating the higher anthropogenic inputs in the creek(Fig 4) .During premonsoon DO levels of 3.8mg/L and 2.8mg/L in Dandi creek was recorded and found to be below the standard permissible CPCB limit (4mg/L ). DO value of less than 4mg/l is considered to be hypoxic and below 0mg/L as anoxic.Low DO levels are detrimental in growth and survival of the fishes in particular. Lesser DO levels reported in another study during same period found mass death of local fish variety due to increased untreated effluent discharge back into the creek (Parmar,2020)was in tandem with the lesser DO levels found in present study

**BOD:-**BOD levels in the water are considered to mark the quality of the water as it indicates increased microbial contamination .In the present study the mean BOD levels were found to vary from 0.55mg/L to 5.35mg/L (Table.1).Between sites the BOD level was found to be consistently higher and beyond CPCB permissible limits for SW-II waters at Navapur coast and Dandi creek. Lower DO and higher BOD levels indicate organic pollution prevalent at the site. Organic pollution coupled with conducive environmental factors in aquatic systems aids the microbial growth (Shanmugam et al., 2007) resulting in decreased levels of oxygen due to consumption by microorganisms for breakdown of complex compounds.

Fig .5 shows temporally the levels of BOD was recorded higher during monsoon at all sites except at Kelwa where the BOD levels were found to be elevated in post monsoon which may be due to only period with high recreational activity at the beach followed by closure of beaches due to COVID 19 global pandemic situation during the study period.Higher levels during monsoon could be attributed to higher land run off from nearby human settlements adding to higher organic loads,intermixing of water between rivers and sea ,which along with lower temperature ,lower salinity and higher oxygen supports microbial growth (Gadhia et al.,2012; Clark, 1986; Joseph and Srivastava,1993) .Satpati coast also showed moderately higher level s of BOD when compared with the levels at Navapur and Dandi sites but was well within the permissible limits. Jalal et al, 2012 found both inorganic and organic load well support the gram negative and hydrocarbon utilizing bacteria in coastal waters of Malayasia.

**Turbidity**:Turbidity in ocean water is a measure of optical clarity of sea water which is influenced by dissolved components and suspended particles in it.The resultant turbidity in surface waters can influence the abundance,distribution and composition of aquatic life forms viz primary producers,zooplankton and fishes in it (Grobbelear, 2009).The mean turbidity levels were found to range from 1.2 NTU - 201.775NTU(Table .1).The lowest was recorded at Kelwa during premonsoon and highest at Dandi creek during Monsoon.Turbidity levels were found to be high during Monsoon season at all sites and was found above the SW II permissible limit of 30 NTU (Fig. 6) but the turbidity levels was found to be within permissible limit during premonsoon and postmonsoon. During monsoon higher turbulence along with rainwater runoff contribute to higher suspended particles in water (Zingde and Govindan ,1997).Between sites the higher levels in creek can be attributed to fresh water influx carrying suspended sand ,silt and clay (Pawar and Kulkarni,2007) which can absorb on nutrients,dissolved organic matter,bacteria and algae and can cause turbidity. (Grobbelear,2009)

**Salinity**:-Salinity of seawater is found to be 35.5 ppt which can vary based on temperature and fresh water addition.In the present Study the salinity was found to range from 27.38 ppt- 35.67 ppt(Table.1). Salinity levels were found to be higher during premonsoon and lowest during monsoon at all sites correlating with amount of rainfall and rate of evaporation.Nutrients like nitrite ,nitrate and phosphate are the crucial elements acting as the growth factors for various life forms .Their levels in marine environment have been studied in shaping the chemical characteristic of marine waters and abundance of primary producers (Raibole and Singh,2011).Ingole and Kadam ,2003 emphasized the effect of tidal cycle in distribution of nutrients in the coastal waters of Mumbai. Nitrogen is present in the aquatic system in dissolved inorganic ionic form as ammonium ,nitrate and nitrite ,which are highly reactive.Along with the natural sources inorganic nitrogen forms are brought into coastal water through various point and non point sources from anthropogenic activities.(Camargo, 2006).The nitrogen flux is balanced by uptake and regeneration between the terrestrial and aquatic environment which in recent years have been imbalanced due to increased human inputs ,rate of nutrient transport to in oceans(Rabalais.2002) and coastal zones.(Duce et al., 2008).

**Nitrite**:-Nitrite is an intermediate product formed in the process of nitrification carried out in aerobic condition by prokaryotes.In the present study the mean nitrites levels was found to vary from 0.088mg/L at Kelwa during postmonsoon to 0.685mgL at Navapur during monsoon.The nitrite levels were found to be higher during monsoon at all sites.

**Nitrate:-**Nitrate is the most stable oxidised form of nitrogen in water. The mean nitrate levels were found to vary from 0 .17 - 2.55mg/L (Table 1). Between seasons the level was found to be higher during monsoon at all sites. During non monsoon months the level was found to be lower during premonsoon at Kelwa coast ,Dandi creek and Satpati coast.The lower levels during premonsoon can be attributed to reduced oxygen levels prevailing at the site which impede the nitrification process.In comparison at Navapur coast the nitrate levels are found to be higher even during pre monsoon which may be due to mixing of effluent continuously discharged from marine outfall and its proximity to the study site and resuspension of nitrates from the sediments due to coastal upwelling.Zingde and Govindan, 2000 also suggested wastewater contribute to the elevated levels of nitrate in the environment.Between sites the nitrate level was found to be highest at Navapur annually followed by at Dandi and Satpati and least at Kelwa coast.(Fig.9)Such observation was also reported by Narayanan et al., 2016 at Cuddalore and Pondicherry coast receiving industrial effluents. The nitrate levels were found to be well within the permissible limit of 10mg/L according to the general coastal water quality standards.

**Ammonia:-**Ammonia is the nitrogenous form that is formed from decomposition of organic compounds and breakdown of urea. Ammonia at a level below 1mg/L is considered to be non toxic (Kamble et al,2011) The mean ammonia levels were found to vary from 0.006mg/L - 1.102 g/L.(Table.1)The level of ammonia was found to increase from postmonsoon to premonsoon and was found to be highest during monsoon.Sewage carrying heavy organic load is considered to increase the level of ammonia on decomposition as observed by Narayanan et al., 2016 along the east coast of India.This was supported in the present study as higher levels of ammonia coupled with elevated BOD levels implying bacterial aided conversion of organic nitrogen into ammonia aided by heterotrophic bacteria.Lower levels during post monsoon could be due oxidation of ammonia followed by reduced oxygen level during premonsoonBetween sites the level of ammonia was found to be higher at Dandi creek (0.434 -1.102 mg/L)with levels exceeding 1mg/L during monsoon due higher organic load run off from the human settlements situated nearby the creek along with the industrial waste. Fig.10 shows levels at Navapur coast (0.298-0.777mg/L)were higher than Satpati coast(0.274- 0.441mg/L) but lower than Dandi creek.Higher levels at Navapur coast may be due to the close proximity of site to effluent discharge,open defecation prevalent at the coast along with the organic load from Dandi creek which further mixes with coastal water during monsoon.Dhage et al reported levels of ammonia to be higher at beaches of Mumbai which are affected by human activities ranging from 1.1 - 2.5 mg/L. At Satpati coast levels were found to vary from 0.271-0.447 mg/L may be due to the influenceof the untreated sewage disposal from the human settlements close to the coast and port related activities. The lowest ammonia levels were recorded at Kelwa coast from 0.0006-0.037 mg/L.

**Phosphates**:-Phosphate levels in marine water is contributed from the freshwater inputs , open defecation, upwelling,uptake by phytoplankton and microbial decomposition of organic matter(Balakrishnan et al.,2017;Amin et al,2017;Satpathy et al,2010).The mean levels of phosphate was found to vary from 0.007 to 0.154 mg/L(Table 1).The lowest was recorded at Kelwa during nonmonsoon periods and highest at Navapur during monsoon period. Seasonally Phosphates level was found to be higher during monsoon at all the stations.(Fig.11) The level was found to be highest at the Navapur beach and remained elevated annually at this station in comparison to other stations. This might be due to the open defecation that is prevalent at the beach which is known to elevate the inorganic phosphate content.Prevalence of open defecation is still a practice in villagers inhabiting coastal regions and therefore act as a point source of contamination in water bodies and causative agent for water borne diseases.(Gokul et al., 2019) Further the Dandi creek water mixed with riverine input opens into Navapur coast might be contributing to the elevated phosphate levels during the monsoon. In Asian countries like India,Bangladesh and Pakistan Amin et al,2017 pointed out increased role of riverine sources in export of nutrients in the form of organic nitrogen and inorganic phosphate from human waste to coastal waters.Between stations followed by Navapur coast the phosphate levels were also found to be higher in Dandi creek than at Satpati and least at Kelwe coast. At Satpati coast elevated levels during monsoon could be due the organic inputs from port activities,various channels that drain sewage and the land runoff from agricultural lands.. Detergents used in cleaning activities at port can further add to the phosphates levels (Tiwari and Nair ,1993).Between sites Fig.11 shows the phosphate levels to be higher at Navapur coast and Dandi creek followed by Satpati and Kelwa coast showing spatial variations.

**Sulphates:-**The sulfates are a major ion in ocean water next to the chloride ions. Sulfates present in water serve as a source of energy for the underlying prokaryotes in the organic rich sediments of the coast. The mean levels of sulphates were found to vary from 284.64 - 1485.36 mg/L.(Table.1) Lower values were observed during monsoon which may be due to dilution by rain water. Sulphates levels may be contributed from industrial effluents, from river runoff, reoxidation of sulphides.(Bhadja and Kundu,2012 )Between sites the level of sulphates were found to be higher at Navapur,Dandi and Satpati coast and least at Kelwa coast.(Fig.12)

**Conclusion:-**The comparative study of physic-chemical parameters in coastal water of Palghar taluka at different locations showed the parameters to vary location wise and seasonally as well.During the study period the physicochemical parameters at Kelwa site was found to show least variation for most parameters throughout the annual cycle. The levels of nutrients viz nitrite ,nitrate ,ammonia and phosphate was found to be higher during monsoonalongwith increase in BOD at Navapur, Dandi creek and Satpati coast indicating higher influence of anthropogenic activities along the regions from industries, human settlement and port related activities in the coastal waters. Higher BOD levels indicate the organic load in the coastal water which can support the microbial growth which might further deteriorate the condition at these sites. This study at different coastal locations along Palghar taluka simultaneously can act as baseline information in understanding the presence of contaminants in different appalling sites and further for biomonitoring studies.

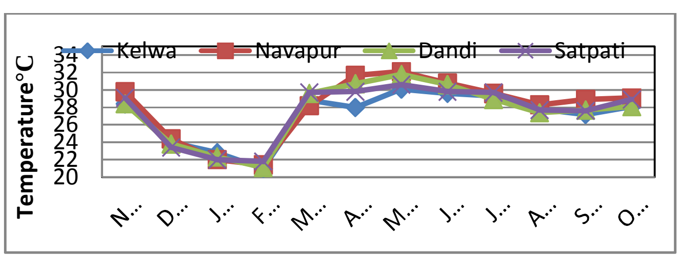


Fig. Monthly variation in Temperature in water at different sites

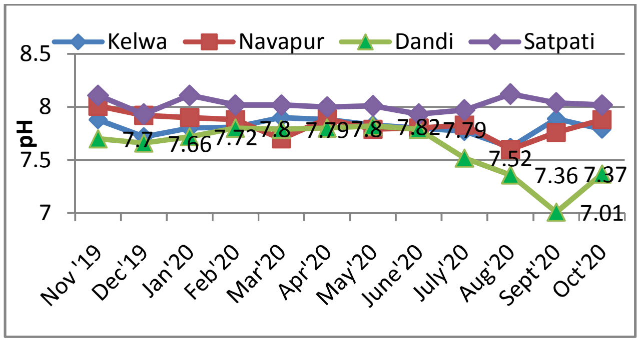


**Fig: Monthly variation in pH in water from 4 different sites**

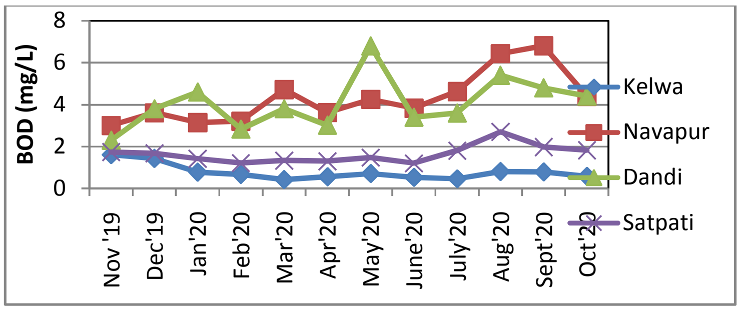


**Fig. Monthly variation in BOD levels in water at different sites**

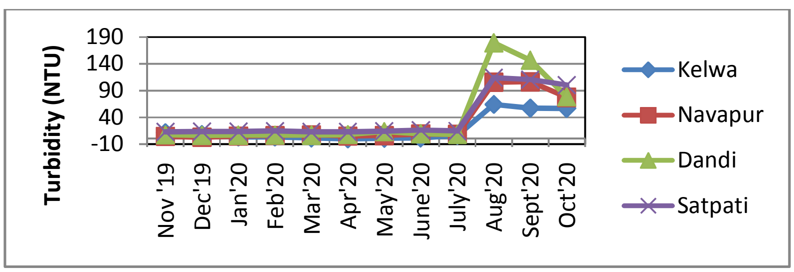


Fig. Monthly variation in turbidity in water at different locations

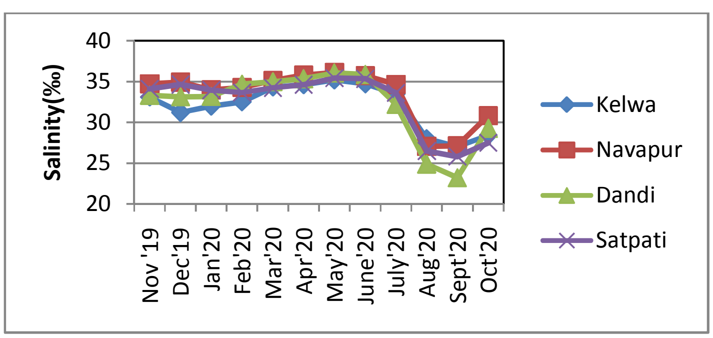


Fig. Monthly variation in Salinity in water in different sites

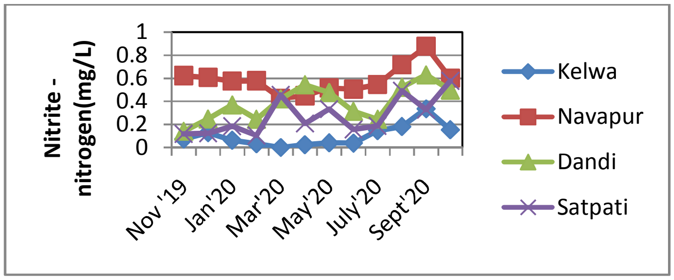


**Fig. Monthly variation in Nitrite-nitrogen at different sites**

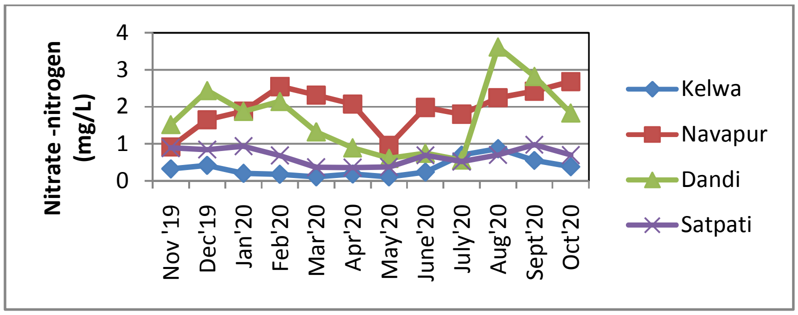


**Fig. Monthly variation in Nitrate-nitrogen at different sites**

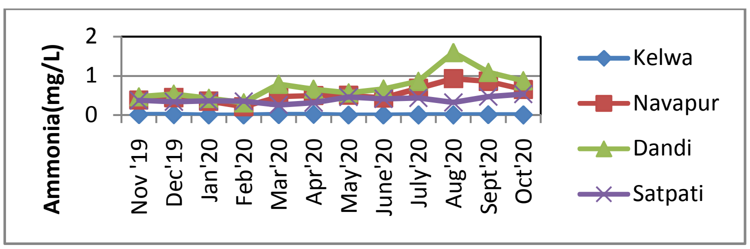


**Fig. Monthly variation in Ammonia-nitrogen at different sites**

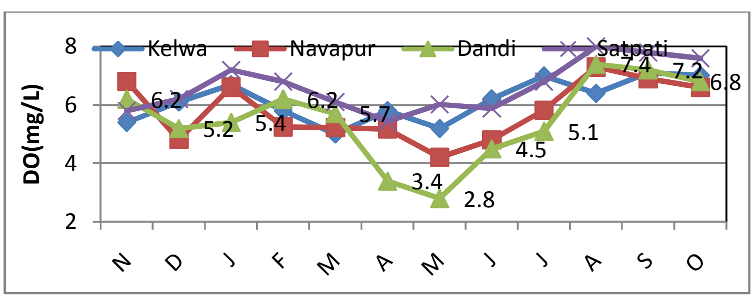


**Fig. Monthly variation in DO (mg/L) in water at different sites**

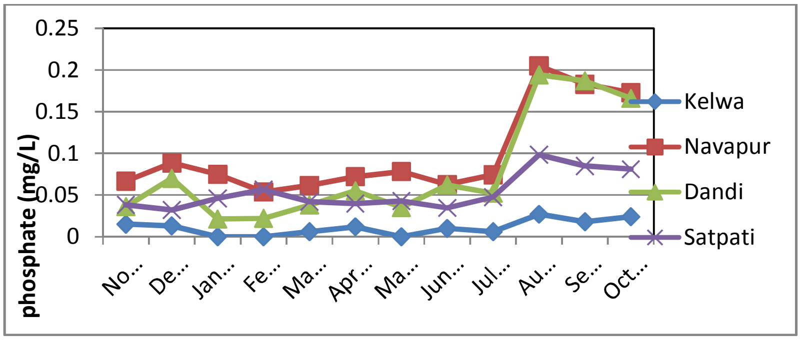


**Fig. Monthly variation in Phosphate phosphorus at different sites**

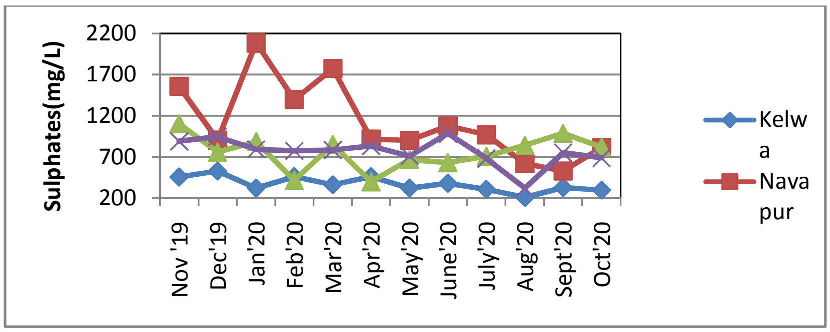


**Fig. Monthly variation inSulphates at different sites**

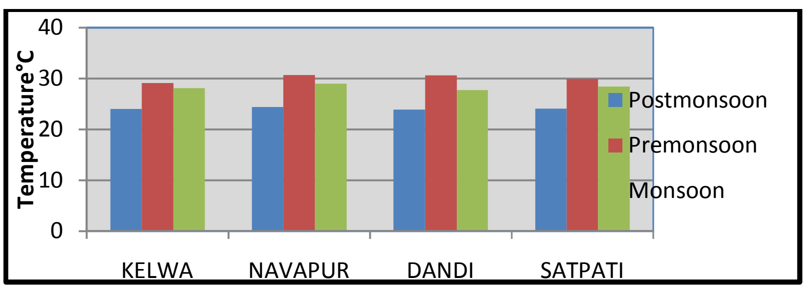


**Fig .2: Mean seasonal variation in Temperature at different sites**

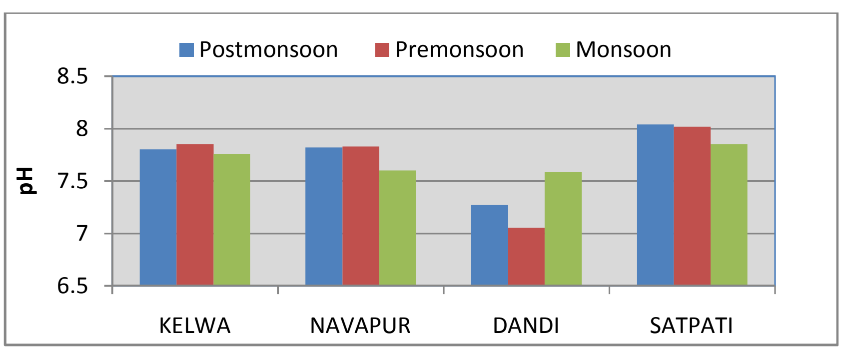


**Fig. 3: Mean seasonal variation in pH at different sites**

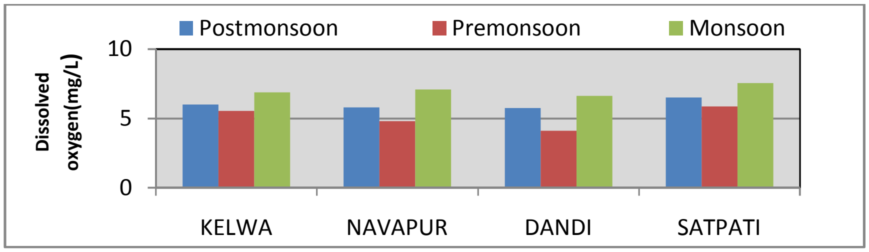


Fig.4: **Mean seasonal variation in DO levels in water at different sites**

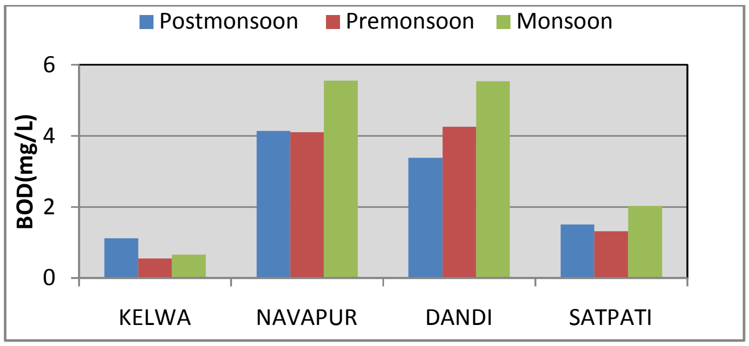


**Fig.5: Mean seasonal variation in BOD levels in water at different sites**

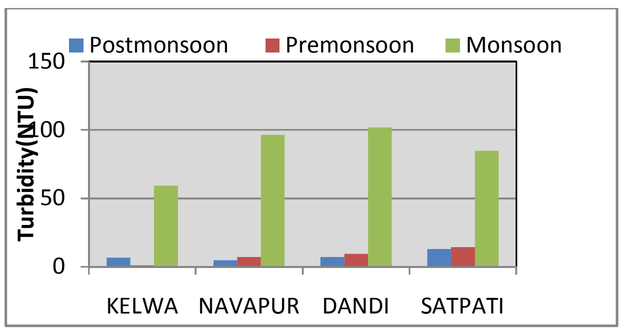


**Fig.6:Mean seasonal variation in Turbidity in water at different sites**

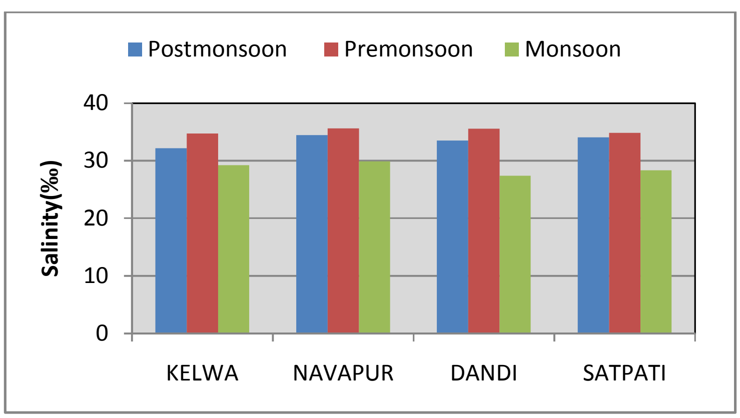


Fig.7: **Mean seasonal variation in Salinity at different sites**

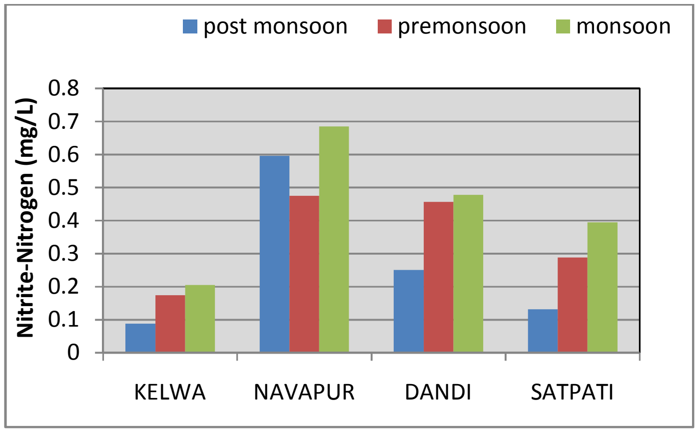


Fig.8: **Mean seasonal variation in Nitrite –nitrogen at different sites**

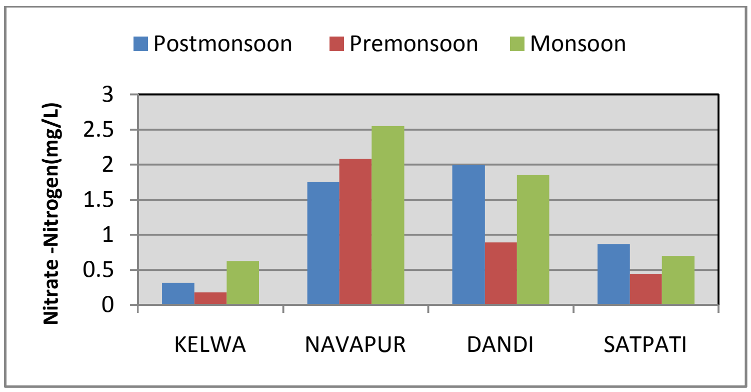


**Fig.9: Mean seasonal variation in Nitrate-Nitrogen at different sites**

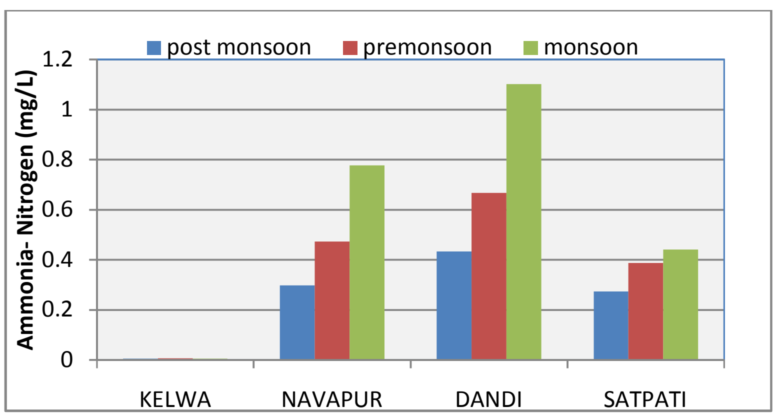


**Fig.10: Mean seasonal variation in Ammonia-Nitrogen at different sites**

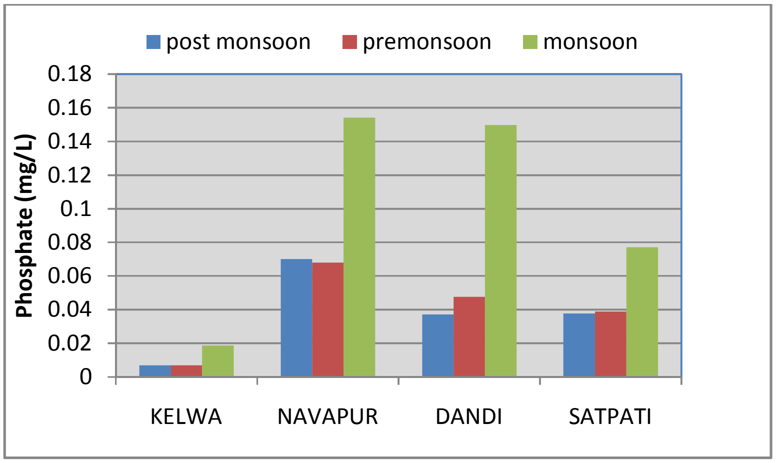


Fig.11: **Mean seasonal variation in Phosphate –phosphorus at different sites**

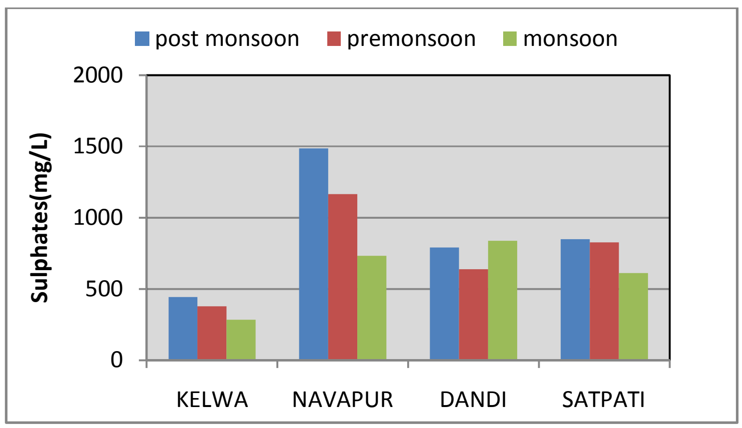


Fig.12: **Mean seasonal variation in Suphates at different sites**

**Table.1 :**The average and standard deviation values of physico -chemical parameters during different seasons at different sites. Value for standard deviation is given (in paranthesis)

| | **PARAMETERS** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SITES (SEASONS)** | **Temp °C** | **Turbidity (NTU)** | **pH** | **DO (mg/L)** | **BOD (mg/L)** | **Salinity (‰)** | **$NO_2^-$ - N (mg/L)** | **$NO_3^-$ - N (mg/L)** | **$NH_3$-N (mg/L)** | **$PO_4^-$ -P (mg/L)** | **$SO_4^-$ (mg/L)** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Postmonsoon** Kelwa | **24.05 (±3.1)** | **6.705 (± 3.8)** | **7.8 (±0.06)** | **6 (±0.54)** | **1.22 (±0.46)** | **32.2 (±0.80)** | **0.088 (±0.03)** | **0.317 (±0.10)** | **0.006 (±0.07)** | **0.007 (±0.01)** | **441.7 (±86.** |
| Navapur | **24.4 (±3.8)** | **4.905 (± 1.3)** | **7.8 (±0.04)** | **5.8 (±0.98)** | **4.14 (±0.04)** | **34.47 (± 0.41)** | **0.596 (±0.02)** | **1.75 (±0.67)** | **0.298 (±0.13)** | **0.070 (± 0.01)** | **1485.36 (±486.8)** |
| Navapur | **24.4 (± 3.8)** | **4.905 (± 1.3)** | **7.8 (± 0.04)** | **5.8 (±0.98)** | **4.14 (±0.04)** | **34.47 (± 0.41)** | **0.596 (± 0.02)** | **1.75 (±0.67)** | **0.298 (±0.13)** | **0.070 (± 0.01)** | **1485.36 (±486.8)** |
| Dandi | **23.9 (± 3.1)** | **6.95 (± 0.7)** | **7.27 (± 0.12)** | **5.75 (±0.52)** | **3.38 (±1.02)** | **33.5 (± 0.73)** | **0.251 (± 0.09)** | **1.99 (±0.39)** | **0.434 (±0.09)** | **0.037 (±0.02)** | **790.75 (±288.1)** |
| Satpati | **24.07 (± 3.4)** | **13.83 (± 0.7)** | **8.04 (± 0.08)** | **6.5 (±0.62)** | **1.51 (±0.24)** | **34.07 (±0.04)** | **0.132 (± 0.03)** | **0.865 (±0.13)** | **0.274 (±0.15)** | **0.037 (±0.02)** | **849.62 (± 80.67)** |
| **Premonsoon** Kelwa | **29.12** | **1.2 (±** | **7.85** | **5.5 (±** | **0.55** | **34.7** | **0.175** | **0.179** | **0.007** | **0.007** | **379.9** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (± 0.9) | 0.5) | (± 0.04) | .55) | (±0.11) | (±0.37) | (± 0.09) | (±0.06) | (±0.01) | (± 0.005) | (±57.93) |
| Navapur | 30.7 (± 1.7) | 7.087 (± 1.6) | 7.83 (± 0.2) | 4.8 (± .47) | 4.105 (±1.27) | 35.67 (±0.42) | 0.475 (± 0.04) | 2.04 (±1.01) | 0.473 (±0.03) | 0.068 (±0.007) | 1166.42 (±410.7) |
| Dandi | 30.6 (± 0.8) | 9.55 (±1.44) | 7.05 (± 0.31) | 4.1 (±1.27) | 4.255 (±1.72) | 35.56 (±0.50) | 0.456 (± .09) | 0.89 (±0.31) | 0.668 (±0.09) | 0.047 (± 0.01) | 367.9 (±187.8) |
| Satpati | 29.9 (± 0.4) | 14.22 (±1.44) | 8.02 (± 0.07) | 5.86 (±0.29) | 1.325 (± 0.11) | 34.89 (± 0.57) | 0.288 (± 0.13) | 0.44 (±0.16) | 0.388 (±0.13) | 0.039 (±0.003) | 827.16 (±114.8) |
| **Monsoon** Kelwa | 2.81 (± 0.8) | 59.66 (± 4.1) | 7.76 (± 0.11) | 6.88 (±0.32) | 0.66 (± 0.1) | 29.22 (±2.91) | 0.020 (± 0.08) | 0.624 (±0.20) | 0.037 (±0.00) | 0.018 (±0.01) | 284.64 (±53.4) |
| Navapur | 28.97 (± 0.5) | 96.54 (±16.6) | 7.6 (± 0.12) | 7.1 (±1.09) | 5.565 (±1.22) | 29.9 (±3.61) | 0.685 (± 0.14) | 2.55 (±0.28) | 0.777 (±0.13) | 0.154 (±0.06) | 732.96 (±197.1) |
| Dandi | 27.79 (± | 101.77 (±3 | 7.59 (± | 6.62 (±1. | 5.53 (± | 27.38 (± | 0.474 (± | 1.85 (±1. | 1.102 (±0. | 0.149 (± | 838.73 (±11 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.9) | 3.4) | 0.12) | 04) | 1.4) | 4.09) | 0.16) | 2) | 34) | 0.06) | 4.7) |
| Satpati | 28.47 (±1.0) | 84.83 (±7.04) | 7.85 (±0.12) | 7.5 (±0.52) | 2.03 (±0.44) | 28.35 (±3.56) | 0.395 (±0.17) | 0.698 (±0.14) | 0.441 (±0.08) | 0.077 (±0.02) | 610.49 (±194.2) |

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