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Physico-chemical Water Quality Parameters of Damanganga Estuary, Daman

Monika Dubey[1]* and Piyush Bindra[1]

[1]*Government College Daman, Daman-Kunta Rd, Dunetha, Daman,*
Dadra and Nagar Haveli and Daman and Diu 396210
**Corresponding author E-mail: monika_aqua12@yahoo.co.in*

Abstract

The present study was carried out to study the physico-chemical water quality parameters of Damanganga estuary, Daman collecting and analyzing the samples from Damanganga estuary. The water quality parameters were observed and found to be as water temperature (27.83±0.72) ^{0}C, pH (8.35±0.05), salinity (10.83±2.39) part per thousand (ppt), dissolved oxygen (7.80±0.46) mg l^{-1}, chloride (5157.16±433.47) mg l^{-1}, total hardness (2633.33±147.57) mg l^{-1}, calcium hardness (1322.71±107.80) mg l^{-1}, magnesium hardness (1310.56±108.27) mg l^{-1} and total alkalinity (115±3.86) mg l^{-1}. Study revealed that chloride, total hardness, calcium hardness, and magnesium hardness were outside the range of WHO (1993), CPCB (2007), BIS (2012) and EPA (2009); and the water pollution index (WPI) was of category III (1.202) indicating that the Damanganga estuary was moderately polluted.

Key words: Estuary, Daman, Damanganga, Physicochemical parameters, Water quality, Water pollution index (WPI)

Introduction

Water is the most essential compound of the ecosystem, and its quality depends upon the physical, chemical, and biological characteristics of water. These characteristics are usually based on the utilization of water and its utility in various usages, such as domestic, agriculture, industrial, etc. These uses of water are designated based on water quality guidelines given by the World Health Organization (WHO), the Central Pollution Control Board (CPCB), the Bureau of Indian Standards (BIS), and the Environmental Protection Agency (EPA) for fresh water, coastal and marine water resources. These National and International standards compare with the analysis of water quality parameters; it is the statistical tools that decide whether or not to use the specific activates. The interaction of water quality with both physical and chemical properties plays a significant role in the composition, distribution, and abundance of aquatic communities. The characteristics of water bodies influence the quality of water individually and in combination with various pollutants, thereby influencing the biota in the aquatic web cycle. Many researchers and scientists have analyzed the quality of water based on the different methods of pollution indexing (Miliasevic *et al.,* 2011; Ujjania and Dubey, 2015). Singh *et al.* (2018) observed that the Sutjel River was polluted due to industrial discharge. Similarly, Semy and Singh (2019) found that the range of sulphate, free carbon dioxide (CO_2), biological oxygen demand (BOD), and pH were not within the permissible limits due to contamination of water catchments characterized by heavy metals discharged from coal mining effluents into the Tsurang River.

The variation in water quality parameters influences the natural activity and efficiency of marine organisms in estuary waters at Punnaikayal (Eucharista, 2019), while Malsawmtluanga, (2022) observed parameters of water samples from the different natural springs in Mualthuam 'N' and found that all the water sources are well within the permissible limits of BIS (2012) standards and could be consumed for domestic, agricultural, development, and other purposes. Global warming and sea level rise are also threatening problems in the current climate change scenario, which is also a reason for saline water intrusion into the coastal fresh water aquifers (Sajeena *el al.,* 2022). According to Nirmala *et al. (*2021) the indexing method of water quality in Theni and Dindigul Districts, Tamil Nadu, was analyzed using a weighed arithmetic index method to indicate critical conditions of water that affect the groundwater quality. It was found that the water quality ranged between excellent and unsuitable for drinking. Similarly, the Narmada River's comprehensive pollution index was analyzed and statistical tools were used. Statistical applications identified that pH; conductivity, alkalinity, and hardness are governing the water quality, whereas BOD and chloride have been influencing water quality in densely populated regions (Gupta *et al.,* 2020). The fluctuation of hydrobiological parameters in seasonality was assessed through advanced numerical tools and reflected the portability of water (Babita and Upadhyay, 2022); thus, quality of water and statistical tools represent the overall condition of water resources. With this background, the present study was carried out with the objective of assessing the water quality of the Damanganga estuary and the sustainability of aquatic life in it. The level of pollution is based on the indexing method, particularly the water pollution index (WQI), and it is major concern from the point of the stream and the flora and fauna supported by the estuary.

Materials and Methods

Study area

The present study was carried out at Damanganga estuary, Daman where the Damanganga River joins the Arabian Sea (Estuary), situated at 20°24′46″ N Latitude and 72°50′10″ E Longitude (Fig. 1) for the period of six months (December to May 2021).

Sample analysis

Surface water samples were collected on a monthly basis during the morning hours of 6:30 to 9:00 am from Damanganga estuary, Daman. Sampling was done at a monthly interval for a period of six months, from December 2020 to May 2021. These water samples were used to analyse the important water quality parameters, including water temperature, pH, salinity, dissolved oxygen (DO), chloride, total hardness, calcium hardness, magnesium hardness, and total alkalinity. Out of these parameters, water temperature, pH, and dissolved oxygen (DO) were analysed *in-situ*. For the remaining parameters, water samples were preserved and transported to the research laboratory. Water samples were preserved (acidification with sulphuric acid to pH < 2) in pre-rinsed plastic containers. The sampling containers were labelled and transported on the

Fig. 1 Map of Damanganga estuary, Daman

same day to the laboratory, Department of Zoology, Government College Daman. For the preservation and analysis of surface water samples within 72 hours, the standard methods of APHA (1995) were followed.

Statistical analysis

The water pollution index (WPI) represents the sum of the ratio between the observed parameters and regulated standard values used for the calculation of the WPI in Damanganga estuary to follow the equation (Lyulko *et al.,* 2001):

$$WPI = \Sigma (Ci/SFQS) \times (1/n)$$

Where Ci represents the average monthly concentration of the analysed water quality parameter, SFQS represents the standard values for the water quality standards of coastal water, CPCB, marine coastal water, etc., while n indicates the number of analysed parameters in the research. The statistical analysis of the data and graphic presentations were done in Microsoft Excel 2019.

Results and Discussion

The results of present investigation of water quality parameters and the status of WPI are depicted in Tables 1 and 2. The maintenance of a healthy aquatic ecosystem is dependent on the physico-chemical properties of water. Therefore, assessing the water quality is very important in determining the quality of the ecosystem and its pollution status. The water quality parameters of Damanganga estuary showed fluctuations due to freshwater flow of the river and tidal influx of the sea. Water temperature is important in relation to fish life as aquatic organisms show varied sensitivity. In the present study, the minimum (26.00) °C value of water temperature was observed in December 2020 and the maximum (31.00) °C in May 2021 with an average value (27.83±0.72) °C which was within the limit given by WHO (1993). Similar results were reported by Ujjania and Dubey (2015) in the Tapi Estuary. The water temperature fluctuated because of the intensity of solar radiation, evaporation, and freshwater mixing. Greater solar radiation and high atmospheric temperatures may be the reason in summer, while the lower observed during lower period may be attributed to the cold climate or weather.

Table 2. Classification of water pollution status on basis of water pollution index (WP)

Class	Characteristics	Degree of WPI
I	Very pure	<0.3
II	Pure	0.3-1.0
III	Moderately polluted	1.0-2.0
IV	Polluted	2.0-4.0
V	Impure	4.0-6.0
VI	Heavily impure	>6.0

(Lyulko *et al.,* 2001)

The pH is a measure of the acid-base balance of a solution, specifically the concentration of hydrogen ions (H^+). In aquatic ecosystems, pH is

Table 1. Water quality parameters in Damanganga estuary during the study period

Parameters	Unit	Minimum	Maximum	Average ± SE	Maximum permissible limits	Water pollution index (WPI)
Water temperature	°C	26.00	31.00	27.83±0.72	35[a]	0.133
pH	_	8.20	8.50	8.35±0.05	8.5[b]	0.164
Salinity	ppt	5.00	20.00	10.83±2.39	10-20[d]	0.090
D.O	$mg\ l^{-1}$	6.08	9.44	7.80±0.46	4.0[c]	0.325
Chloride	$mg\ l^{-1}$	3905.00	7080.00	5157.16±433.47	1000[b]	0.086
Total hardness	$mg\ l^{-1}$	2000.00	3000.00	2633.33±147.57	600[b]	0.073
Calcium hardness	$mg\ l^{-1}$	1000.79	1601.27	1322.71±107.80	200[b]	0.110
Magnesium hardness	$mg\ l^{-1}$	998.81	1599.21	1310.56±108.27	100[b]	0.218
Total alkalinity	$mg\ l^{-1}$	100.00	125.00	115±3.86	600[b]	0.003
WPI = Σ (Ci/SFQS) × (1/n)						1.202

a=WHO (1993), b= BIS (2012), c= CPCB (2007) d= EPA (2009)

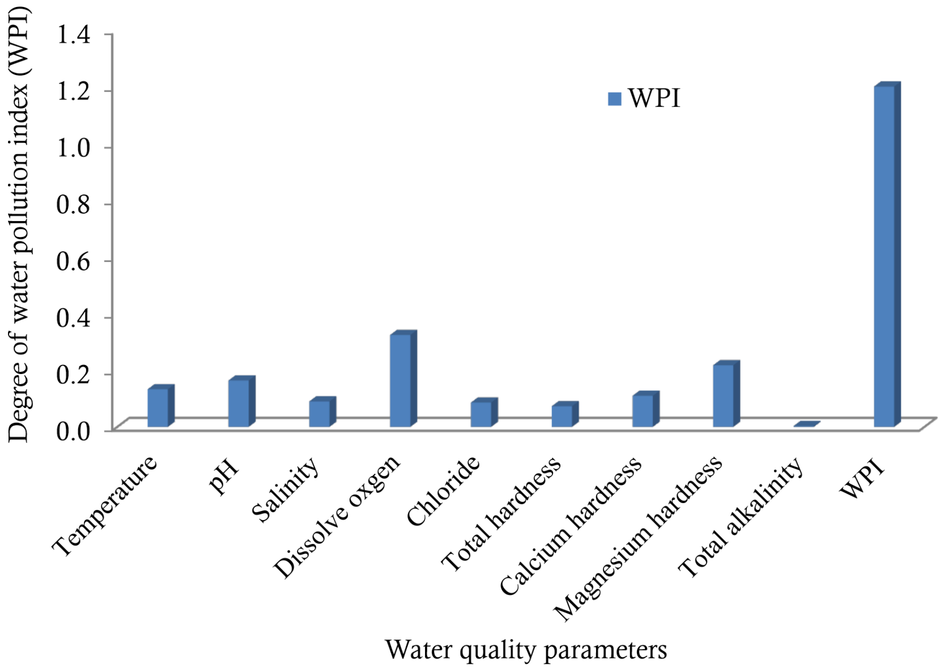

Fig. 2 Graphically representation of water pollution index (WPI)

important for biological productivity. Generally, pH values between 6.5 and 8.5 indicate good water quality. In a study, the pH of the ecosystem was lowest in January 2021 (8.20) and highest in April 2021 (8.50), with an average of 8.35±0.05. These values were within the acceptable range set by BIS (2012). Similar findings were reported by Pradhu *et al.* (2008). The high pH recorded may be due to increased algal growth and photosynthesis, as well as higher temperatures and microbial activity. The low pH may be influenced by freshwater influx and low photosynthetic activity. Salinity is the measurement of dissolved salts in water and it affects the types of plants and animals that can live in an aquatic ecosystem. In a monthly analysis, salinity levels fluctuated greatly, ranging from 5.00 to 20.00 ppt, with an average value of 10.83±2.39 ppt. This variation in salinity was caused by the influx of freshwater and marine water. A study conducted in Punnaikayal, Thoothukudi also found that higher salinity levels were influenced by factors such as higher solar radiation, the influx of marine water, and the decrease in adjacent marine water due to the flow of fresh water in coastal areas (Eucharista, 2019).

Dissolved Oxygen is an important factor for the health of aquatic ecosystems, as it is necessary for the survival of aquatic fauna. In a recent study, the minimum dissolved oxygen level was recorded in May 2021 (6.08) mg l^{-1}, while the maximum level was recorded in December 2020 (9.44) mg l^{-1}. The average dissolved oxygen level was 7.80±0.46 mg l^{-1}, which was within the limit set by the Central Pollution Control Board (CPCB) in 2007. Similar findings were observed in previous studies, where low dissolved oxygen levels were attributed to industrial organic effluents, sewage load, and high temperatures, while high dissolved oxygen levels were attributed to water aeration and low temperatures (Ujjania and Dubey, 2015).

In the present study it was found that chloride levels in water ranged from 3905 to 7080 mg l^{-1} from February to December, with an average value of 5157.16±433.47 mg l^{-1}. These levels exceeded the limit set by BIS (2012) indicating pollution. The high chloride concentration suggests the presence of marine water in freshwater, as well as pollution from sewage and industrial waste. This is consistent with a previous study on water quality in the Tapi estuary (Ujjania and Dubey, 2015).

Total hardness refers to the concentration of certain ions in water, such as calcium, magnesium, and alkaline earth metals. It is a measure of how water reacts with soap, with hard water requiring more soap to lather. In a recent study, the lowest and highest values of total hardness were found to be between (2000 and 3000) mg l^{-1} in the months of January 2021 and May 2021. The average value was 2633.33±147.57 mg l^{-1}, which exceeded the limit set by the Bureau of Indian Standards (BIS) in 2012. The high hardness levels were attributed to the tidal flow and the addition of sewage and detergents from residential areas (Ujjania and Dubey, 2015).

Calcium hardness is a common occurrence in water due to deposits of limestone and other calcium-bearing rocks. The hardness is caused by the salts of calcium and magnesium. In January 2021, the minimum calcium hardness value was 1000.79 mg l^{-1}, while in May 2021; the maximum value was 1601.27 mg l^{-1}. The average value was 1322.71±107.80 mg l^{-1}, which exceeded parameters of BIS (2012). This increase in calcium hardness can be attributed to tidal flow, decomposition of organic matter, and a higher proportion of calcium in the surrounding rocks and soil. Additionally, the addition of sewage water may also contribute to the increase in calcium hardness. A similar study conducted in Punnaikayal estuary, Tamil Nadu, by Eucharista, (2019) who reported similar findings. Magnesium hardness is a common element found in the earth's crust and natural waters. It contributes to the hardness of water along with calcium. In February 2021, the minimum value of magnesium hardness was 998.81 mg l^{-1}, while in March 2021; the maximum value was 1599.21 mg l^{-1}. The average value was 1310.56±108.27 mg l^{-1}, which exceeded BIS (2012) parameters. This suggests that the high concentration of magnesium hardness may be due to the influence of seawater and industrial effluent discharges in estuary water. Andrade *et al.,* 2011 also observed that the concentration of magnesium hardness exceeded the maximum permissible limit in Mangalore coastal water. Similarly, in Punnaikayal estuary, there was a trend of higher concentration during summer months and lower concentration during winter months (Eucharista, 2019).

Total alkalinity refers to the amount of dissolved compounds in water that can shift the pH towards neutrality or alkalinity. It is an important concept in determining a system's ability to buffer against acid impacts. The buffering capacity of a body of water refers to its ability to resist or dampen changes in pH. Alkaline compounds such as bicarbonate, carbonates, and hydroxides in water can remove H^+ ions and lower the acidity, thereby increasing the pH (UNEP, 2006). The change in alkalinity depends on the presence of carbonates and bicarbonates, which in turn depends on the release of CO_2. In a specific study, the minimum and maximum values (100 and 125) mg l^{-1} in January 2021 and December 2020, respectively, mean values (115±3.86) mg l^{-1} of total alkalinity in a river were within the limits set by BIS, 2012 indicating normal levels. However, higher values of total alkalinity were observed, possibly due to the presence of strongly alkaline industrial waste water, sewage, and organic waste releasing CO_2 in the estuary. These factors may have contributed to an increase in carbonate and bicarbonate levels, resulting in an increase in alkalinity (Gupta *et al.,* 2020).

The water pollution index (WPI) is a number that represents the level of pollution in a body of water based on various water quality parameters. In this study, the WPI for the Damanganga estuary was recorded as 1.202, falls under category III, indicating moderately polluted water (Lyulko *et al.,* 2001). This finding is similar to a study conducted in the Borska Reka River in Siberia (Miliasevic *et al.,* 2011).

Conclusions

The present work revealed that WPI (1.202) under the degree of water pollution was moderately polluted and water quality parameters (water temperature, pH, salinity, DO, and total alkalinity) were within the prescribed limits while other parameters (chloride, total hardness, calcium hardness, and magnesium hardness) were beyond the maximum permissible limits which clearly indicates that Damanganga estuary and river water is moderately polluted by industrial effluents, domestic sewage drains and other anthropogenic activities in Damanganga estuary. Need to followed appropriate management policy and rules & regulation to discharge effluents.

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