
Chapter 2

Literature Review

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

One of the UN's global Sustainable Development Goals (SDGs) is "Life below water," which aims to conserve marine and coastal regions and ecosystems while also reducing marine pollution and its potentially negative effects. It is closely related to and interrelated with other SDGs (Xiong *et al.*, 2023). Yet, a lot of attention has recently been paid to researching how human activity affects the physico-chemical properties and dissolved heavy metal levels of coastal waters (Athira *et al.*, 2022; Hardikar *et al.*, 2017; Kumkar *et al.*, 2023; Naik *et al.*, 2020; Pasumpon *et al.*, 2023; Patra *et al.*, 2023; Pattanaik *et al.*, 2019; Sahoo & Swain, 2023; Vase *et al.*, 2018) and sediment (Saha *et al.*, 2024; Thalayappil *et al.*, 2024; Vidya *et al.*, 2024) to ascertain the characteristics and productivity of the sediment and coastal water surrounding the Indian coast.

Heavy metals are extremely poisonous and resistant to degradation, which makes them a major danger to aquatic ecology and the safety of water environments. For the management of water resources and environmental protection, heavy metal concentrations must be quickly acquired and predicted. At different locations in the coastal region of the Yangtze River estuary, measurements of heavy metal concentrations i.e., Cr, Ni, Cu, Pb, Zn, Cd and physico-chemical characteristics of water quality, such as temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), and salinity, were made. Shipping and vessel emissions were usually regarded as sources of Pb and Cu, whereas home and industrial sewage were the primary sources of Cr, Ni, Zn, and Cd in the steel sector (Zou *et al.*, 2024).

Ten significant river mouths in Cote d'Ivoire, Gulf Guinea, West Africa, were examined for physico-chemical characteristics and trace metal concentrations. In 2020, sampling was done during the dry season. The findings demonstrated that the river mouths' average temperature (25.5 °C) and pH (8.70) values indicate adequate water quality. TDS (23.2 g L⁻¹), salinity (47.7 mg L⁻¹), DO (6.23 mg L⁻¹), nitrite (NO₂⁻) (0.04 mg L⁻¹), nitrate (NO₃⁻) (5.10 mg L⁻¹), phosphate (PO₄³⁻) (1.32 mg L⁻¹), and sulfate (SO₄²⁻) (998 mg L⁻¹) were the physico-chemical concentrations. The levels of the three trace metals under study Zn, Cr, and Cu were higher than the world health organisation (WHO's) recommended thresholds for drinking water, raising concerns about possible risks to public health and the environment (Kouassi *et al.*, 2024).

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

In Guangdong Province (GD), China, surface seawater was subjected to three seasons of heavy metal including Hg, Pb, As, Zn, and Cu and physico-chemical component (pH, DO, salinity, and COD) measurements in 2019. Overall, GD's east coast had higher average pollution levels for Cu, As, and Zn, while its west coast had higher average pollution levels for Hg and Pb. The distribution features of physico-chemical variables were influenced by the water quality of the Pearl River. In the centre region, there were greater COD levels but lower salinity, DO, and pH values. While COD increased over the summer, DO decreased during that time (Kang *et al.*, 2024). Pb varied from 21.15 - 52.69 $\mu\text{g g}^{-1}$, Zn from 19.32 - 175.1 $\mu\text{g g}^{-1}$, and Cd from 0.87 - 2.031 $\mu\text{g g}^{-1}$, according to a study from the Algerian central coastal zone of North Africa. For Pb, Zn, and Cd, the contamination factors varied from 0.62 - 1.55, 0.2 - 1.85, and 1.74 - 4.04, respectively. Upon examination of sediment samples, these three metals are found at the majority of the sites under investigation (Belhouchet *et al.*, 2024).

The Lagos Lagoon, located on the African coast and the eastern arm of the Gulf of Guinea, was used to study the effects of human activity on physico-chemical parameters and heavy metals. The average physico-chemical characteristics are salinity (12.80 ppt), DO (7.93 mg/l), pH (7.86), and temperature (27.34°C). Except for Pb and Cd, all metal concentrations for the heavy metal under study Fe, Pb, Cu, Zn, Cd, and Ni are within the allowable limits set by the Federal Environmental Protection Agency (FEPA) (Nubi *et al.*, 2024).

Aquatic species find vital habitats for reproduction and multiplication in coastal waters. In addition to endangering human health, pollutants have the potential to seriously destroy the biodiversity and ecosystem of coastal waterways. From Hainan Island in China, the spatiotemporal pattern of coastal water pollution was evaluated. The findings indicated that the northern coastal region was mostly responsible for the decreased temperature. In the coastal regions to the north, east, and south, TSS levels were lower. The coastal regions of WenChang in the east and LinGao in the north were mostly home to the higher DO values. In general, BOD₅ was modest (> 0.001 mg/L at a few east and west locations). The south had greater values for Cd, Zn, Se, and As values were lowest in this area. In comparison to the north and west, Ni was higher in the east and south (Du *et al.*, 2024).

Research conducted in Maharashtra on the Malvan coast which has abundant coral reefs and biodiversity makes it one of Maharashtra's Marine Protected Areas (MPAs). The range of

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

DO was 5.52 to 7.69 mg L⁻¹. The water's temperature (avg. 30.91) occurred during the pre-monsoon (PRM), while the minimum (avg. 27.37 °C) occurred during the monsoon (M), as would be expected for a tropical coast. During the M, TSS concentration was highest (avg. 83.78 mg L⁻¹) and lowest (avg. 20.89 mg L⁻¹), PRM (avg. 28.50 mg L⁻¹), indicating seasonality in the data (Hardikar *et al.*, 2017). The mean salinity of the Bay of Bengal coastal water varied from 13.10 - 23.64 ppt, with a PRM season peak. The M season had the lowest salinity, which might be explained by the impact of precipitation and the large input of fresh water into the estuary. There was a variation in the mean temperature between 26.98 - 30.43 °C. The alkaline conditions were indicated by a pH variation of 7.77 to 8.25. During the PRM, the seaward stations recorded a higher peak value than the upstream sites. The TSS value ranged from 7.65 mg L⁻¹ to 41.57 mg L⁻¹ (Naik *et al.*, 2020).

For a year (February 2006 to January 2007), research on the seasonal fluctuation in the physico-chemical parameters of the coastal waters was conducted along the Kalpakkam coast. It was shown that during the North East (NE)-M and post-monsoon (POM) seasons, freshwater intake had a major impact on the coastal water. While salinity was at its lowest point during the NE-M, concentrations of all nutrients and DO were comparatively high. In comparison to the pre-Tsunami era from this shore, the current observed values of nitrate, phosphate, silicate, and turbidity are noticeably high (five to ten times) (Satpathy *et al.*, 2010).

In the designated study region, samples of coastal water were gathered and examined for water quality. Thus, the Gulf of Khambhat Region was studied for sea surface temperature, salinity, pH, EC, alkalinity, turbidity, salinity, TSS, DO, BOD, COD, Cl⁻, SO₄²⁻, and total organic carbon (TOC). Four distinct places were used to gather the samples: Ghogha, Dumas, Dahej, and Purna. According to the research, human disturbances and the growth of various activities that increase point and non-point stormwater runoff are directed straight into coastal areas, degrading the quality of the water (Singh *et al.*, 2022). One of the least researched marine ecosystems is the Swarnamukhi River Estuary (SRE) and the surrounding sea in Nellore, on the southeast coast of India, particularly for physico-chemical attributes. From 2014 to 2017, seawater samples were taken monthly from five sites to evaluate its physico-chemical properties. Anthropogenic outflows, including farms that practice aquaculture and settlement (built-up) effluents, were the main causes of variability (Ratnam *et al.*, 2022).

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

To determine the fluctuations in physico-chemical characteristics during a monsoonal cycle of the year, seasonal observations on water parameters were conducted spanning an area of approximately 30 km² in the coastal waters of Kalpakkam, on the southeast coast of India. The majority of the metrics showed notable seasonal and geographical variation. It was discovered that during the northeast M and POM seasons, freshwater inflow from the adjacent backwaters had a major impact on the coastal water. During the observation, a slight increase in pH was seen from the shoreline towards the offshore. In comparison to the summer, relatively low salinity values were found throughout the PRM and POM (Satpathy *et al.*, 2010).

According to the investigations, seasonal fluctuations were seen in the physico-chemical parameters of the water and samples in the coastal waters of Thondi, India. The purpose of the study was to assess the physico-chemical parameters of the water quality in the coastal waters of Thondi, Palk Bay, for a year, from January to December 2015. Standard procedures were used to analyze a variety of parameters, including temperature, pH, salinity, TDS, NO₂⁻, NO₃⁻, silicate [SiO_{2+n}]²ⁿ⁻, PO₄³⁻, and total phosphate (TP). The salinity (30.1 - 34.5 ppt), pH (8.0 - 8.2), turbidity (28 - 59 NTU), TSS value (58.28 - 95 mg/L), DO (4.01 - 5.61 mg/L), BOD (0.16 - 2.19 mg/L), COD (0.87 - 19.9 mg/L), and Cl⁻ (17252 - 17850 mg/L) were the ranges of water temperature and salinity. pH (7.7-8.1), total nitrogen (TN) (4.14 - 9.80 µg/g), total phosphorus (TP) (1.40 -2.58 µg/g), and TOC (1.70 - 5.84 mg/g) were measured in sediment samples (Hullas *et al.*, 2023).

The Gulf of Mannar's coastline area was evaluated for the quality of its sediment and seawater at several locations. From 2016 to 2017, physico-chemical parameters and environmental variables like salinity, pH, temperature, depth, DO, TSS, TN, and TP, as well as sediment soil characteristics like soil pH, and TOC were analyzed on various seasonal changes. The Gulf of Mannar's chosen stations exhibit significant variations in temperature, pH, salinity, and depth as a result of M patterns. During the POM and summer seasons, there was a positive correlation found between salinity, DO, sand, pH of the sand, water pH, and sand with the coastal waters of Vembar and Tuticorin (S-4 & S-5). However, throughout the PRM and M seasons, Mandapam (S-1), Rameshwaram (S-2), and Keelakarai (S-3) stations showed a negative correlation with other measures including silt, TN, TP, TOC, and clay (Ravichandran *et al.*, 2022).

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

An assessment of pollution levels based on the physico-chemical properties of sediment in the Indian coastal region of Kalpakkam. Starting in 2019, the study was conducted for a year at twelve sample locations throughout the Kalpakkam coastline zone. Nutrients in the sediment, including TOC, phosphorus (P), potassium (K), nitrogen (N), and the distribution of particle sizes, were measured for each season. Particle size cumulative percent of sediments (from 9.01 to 9.39%), TOC (0.11 to 0.88%), pH (7.55 to 8.99), EC (0.99 to 4.98 dS/m), N (21.74 to 58.12 kg/ha), P (7.5 to 12.9 kg/ha), and K (218 to 399 kg/ha) were all measured during the research period. Research suggests pollution from human and natural sources (Pandion *et al.*, 2022).

The study suggests contamination occurs from both natural and man-made sources and aims to determine how seasonal variations affect the pollution loads of the sediment in a coastal area in terms of its physico-chemical properties. The research also covers the effects of natural phenomena like the M and manmade activities like agriculture and urbanization on the sediment quality of the coastal region. The pH (7.96 - 9.45), EC (2.89 - 5.23 dS/m), N (23.98 - 57.23 mg/kg), P (7.75 - 11.36 mg/kg), K (217 - 398 mg/kg), TOC (0.35 - 0.99 %), and sediment proportions (8.91 - 9.3 %) were the nutrients observed to have changed in the sediment. The main causes of pollution are human activities and heavy rain (Pandion *et al.*, 2023).

The character of the depositional region may be qualitatively evaluated by analysing OM, which indicates variations in previous production. It is primarily considered that primary productivity, vertical fluxes, sedimentation, chemical stability, degradation rates of particulate organic carbon, and bottom-water oxygen concentrations govern the preservation and burial of OM (Thalayappil *et al.*, 2024). There was a maximum TOC content of 0.89%. To evaluate the organic fraction's contribution to the movement, deposition, and retention of nutrients and metals, TOC content studies in sediments are essential (Thalayappil *et al.*, 2024).

The purpose of the study was to determine how human activity affected the physico-chemical characteristics and heavy metal concentrations in surface water and sediment samples from the Cuddalore coast in Southeast India. The samples were taken throughout the year (January through December 2010), and conventional techniques were used to analyze them for heavy metals (Cd, Cu, Pb, and Zn) and physico-chemical parameters (temperature, pH, salinity, NO_3^- , NO_2^- , ammonia (NH_3), P, and $[\text{SiO}_{2+n}]^{2n-}$). The findings demonstrated that the research area's samples' physico-chemical properties and heavy metal content fluctuated seasonally and

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

geographically (Mathivanan & Rajaram, 2014). In comparison to other seasons, the M season had greater quantities of heavy metals in the water and sediment samples of the research region. $Pb > Cu > Cd > Zn$ was the heavy metal order found in water and sediment samples. The study also demonstrates that land-based anthropogenic inputs, resulting from sewage, industrial, and agricultural waste discharged into estuarine regions, which carries the wastes into coastal areas during tidal action, are the primary cause of heavy metal pollution at the Cuddalore coast (Mathivanan & Rajaram, 2014).

In the harbouring zones in the Digha coastal area of west Bengal, India, the inquiry aims to uncover the seasonal fluctuations in physico-chemical parameters and heavy metal concentrations in the winter and summer. In summer, the area showed greater pH, TDS, EC, BOD, Na, K, and TOC in winter, the area displayed higher DO, total alkalinity (TA), and total hardness (TH). Summertime concentrations of heavy metals such as Cd, Zn, Mn, and Cr were higher than allowed, but wintertime concentrations of Cu, Pb, Ni, and Ar were higher than allowed. It could be concluded that there is a considerable seasonal variation in the content of heavy metals and physico-chemical characteristics. Summertime saw greater values for some physico-chemical parameters, such as pH, EC, TDS, BOD, Na, K, and TOC, while winter brought higher values for others, such as DO, and TH (Patra *et al.*, 2023).

An investigation was conducted to determine the effects of human activity on the trace metal content of the water and sediment from the Netravathi-Gurupur estuary in India. $Fe (592.71) > Mn (98.35) > Zn (54.69) > Cu (6.64) > Cd (3.24) > Pb (2.38) > Cr (0.82)$ was the descending order of the metal concentrations investigated ($\mu\text{g/L}$) in the water, and $Fe (11,396.53) > Mn (100.61) > Cr (75.41) > Zn (20.04) > Cu (12.77) > Pb (3.46) > Cd (0.02)$ in the sediment. Compared to non-monsoon seasons, M-season metal concentrations were greater. According to pollution indices, the sediment had low to moderate levels of contamination. Reduced metal concentration is linked to the lockdown enforced by COVID-19 (Saha *et al.*, 2024).

During the PRM and POM seasons, surface sediment samples were gathered from five distinct traverses located off Chennai, India, along the inner shelf of the Bay of Bengal. When comparing PRM to POM seasons, the physico-chemical parameters under study revealed higher values during the former. This study unequivocally demonstrated that the Chennai

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

shoreline was heavily contaminated with heavy metals. According to the geo-accumulation index, the sediments are high to significantly contaminated with Cd and Cu over both seasons. The findings point to human sources as a moderate source of Cd and Cu intake into the Chennai coast's inner shelf (Raju *et al.*, 2011).

According to the study by Vineethkumar *et al.* (2020), lithogenic variables influence the distribution and enrichment of trace elements in Kerala's coastal environment. The majority of the enrichment of trace elements in the coastal area is a result of air deposition, natural weathering processes, or crustal materials. In the Kerala coastal area, trace elements such as zinc and arsenic are found to be substantially concentrated, whereas nickel and titanium are found to be less abundant. Anthropogenic factors, such as industrial processes, sewage disposal, fertilizer application in agricultural areas, and home and city trash, may also have an impact on the enrichment of trace elements in Kerala's coastal ecosystems. The quality of sediment samples in Kerala's coastal environment is not very harmful, as shown by the pollution indices, and none of the trace element concentrations were higher than allowed. The concentration of the trace elements in the sediment samples has been impacted by the physico-chemical characteristics.

Fe and Cd had the greatest and lowest variations in the heavy metal readings. The following diminishing pattern was seen in their average values: Fe > Cu > Zn > Pb > Cr > Ni > Cd. According to this study, land-based anthropogenic sources, such as the discharge of industrial, agricultural, and slum sewage into the Buckingham Canal, which then empties into the sea through backwaters, are the main source of metals at the Kalpakkam coast. This is especially true during the northeast M season. Cu, Pb, and Zn concentrations were found to be higher during the M season (October–January) than they were throughout the rest of the year. The M season saw an increase in the sediment's organic carbon content, suggesting that backwater flow and land runoff contributed to this rise (Satpathy *et al.*, 2012).

The Tupilipalem Coast, on the southeast coast of India, provided sediment samples from twelve locations. The sediment samples revealed the presence of some heavy metals, including iron (Fe), manganese (Mn), Cr, copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), and cadmium (Cd). The Tupilipalem Coast's surface sediment was found to be highly polluted with Fe, Mn, Cr, Cu, Ni, Pb, and Zn, according to the Geoaccumulation Index. The results of the enrichment

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

factor calculation indicated a moderate enrichment with Cr, Cu, and Ni and a large enrichment concerning Pb, Zn, and Cd. The enrichment factors of average contents show a declining trend: $Cd > Pb > Zn > Cu > Cr > Ni > Mn > Fe$. Due to the impact of many external sources, such as industrial operations, agricultural runoff, and other anthropogenic inputs, the PLI values of the Cd exhibit greater (>1) values (Ganugapenta *et al.*, 2018).

The study by Gandhi *et al.* (2024), examines the effects of industrial, anthropogenic, and other factors on surface sediment samples along the southeast coast of Tamil Nadu, extending from Puducherry to Cuddalore. Except Cr, which is much above the range of widespread pollution in POM times, contamination levels in Puducherry and Cuddalore coastal regions were moderate to high compared to PRM periods. The results of the sampling of sediments from Puducherry and Cuddalore offshore indicated moderate to significant pollution. Most components of trace metal levels in sediments show very low levels of contamination, with the noteworthy exception of Pb.

The study focused on the beach sediments in the Andaman and Nicobar archipelago's possible level of pollution and ecological danger. The trace metal mean concentration displays the following decreasing order: The following sectors are divided into four groups: Rutland Island, $Ni > Fe > Pb > Zn > Co > Cr > Cu > Mn$, Little Andaman, $Ni > Pb > Zn > Co > Cr > Fe > Cu > Mn$, and Great Nicobar Island, $Fe > Ni > Cr > Pb > Zn > Co > Mn > Cu$. The North Andaman sector is $Pb > Zn > Ni > Co > Cr > Fe > Cu > Mn$, while the Middle Andaman sector is $Fe > Ni > Pb > Zn > Cr > Zn > Mn > Cu$. The following is how the enrichment factor displays the metal enrichment trend: Pb, Ni, Cr, Cu, Mn, and Zn. The most noteworthy trace elements in the beach sediments, according to the heavy metal data, are Fe, Mn, Pb, and Cu. Except for lead, all metals in the geo-accumulation index of metals fall into an uncontaminated group. The moderate to strong group is indicated by the degree of silt contamination. The ecological risk and sediment pollution index show that the sediment is in a natural category with minimal pollution risk (Anbalagan *et al.*, 2024).

The overall amount of reactive nitrogen produced from land that enters the ocean is mostly controlled by coastal sediments, and in ecosystems that are sensitive to anthropogenic threats, the significance of these sediments increases. The primary nitrogen sink in marine ecosystems has been determined to be sedimentary denitrification and anaerobic ammonium

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

oxidation with NO_2^- has been recognized as a major factor regulating the nitrogen pool in these settings. The investigation of the microbial biota in the coastal sediments of Baja California, located in northwest Mexico was done. Based on the taxonomic characterization using 16S rRNA gene sequencing, many clades of *Desulfobacterota* were identified as possible bacteria (Avendaño *et al.*, 2024).

The composition and functionality of coastal sediments can be impacted by heavy metals. The amount of dissolved organic matter (DOM) in coastal sediments is a significant factor in defining the microbial community makeup and the toxicity of heavy metals. It is unknown, meanwhile, how heavy metals impact DOM's interactions with microbial populations. Here, we looked at how heavy metals affected the composition of DOM and the structure of the microbial community, which includes bacteria and archaea, in the surface sediments of the Beibu Gulf in China. First, the results showed that the heavy metals causing pollution in the study region were Cr, Zn, Cd, and Pb. Additionally, there was a noticeable difference in the DOM chemical composition between the polluted and uncontaminated areas, with the former having a greater average O/C ratio and the latter having a higher predominance of highly unsaturated compounds and carboxyl-rich alicyclic molecules. This suggests that in contrast to the uncontaminated region, the DOM in the contaminated area was more resistant. There were no appreciable changes found in the structure of bacteria and archaea, or in the diversity of bacteria, between the two locations, except for differences in archaeal diversity. However, our co-occurrence network analysis showed that the predominant bacterial and archaeal groups in the polluted region were B2M28 and *Euryarchaeota* (Wang *et al.*, 2024).

According to Che *et al.* (2024), hydrodynamic processes, which most likely contain a variety of microorganisms and heterogeneous TOC in the ocean, are essential in propelling the transmission of sediments. Variations in benthic shear pressures altered the principal microbial assemblages and gene abundances in resuspended sediments, leading to diversification following ongoing hydrodynamic erosion. Compared to anaerobic bacteria, aerobic bacteria were more likely to be eroded out of sediments at lower shear forces. High-throughput barcoded pyrosequencing of the 16S rRNA gene was utilized to comprehend the diversity and dispersion of the bacterial population in the coastal sediment of Bohai Bay, China. The sand samples were processed to extract their metagenomic DNA. Throughout the six coastal

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

sediments, *Proteobacteria* was the predominant phylum, followed by *Bacteroidetes*, *Chloroflex*, γ -*Proteobacteria*, and δ -*Proteobacteria* (Wang et al., 2015).

Researchers explored the bacterial diversity of sediment from a retention basin that was consistently contaminated by oil in the Berre lagoon (Etang-de-Berre, France). The *Proteobacteria* phylum (*Gamma*-, *Delta*-, *Alpha*-, *Epsilon*-, and *Betaproteobacteria*), the *Bacteroidetes* and *Verrucomicrobium* groups, the *Spirochaetes*, the *Actinobacteria*, and the *Cyanobacteria* phyla were found to be the most prevalent types of bacteria in the bacterial community (Paissé et al., 2008). The disturbed zone, near estuary zone, and far estuary zone of Hangzhou Bay, one of the most severely polluted bays in China, are where the coastline surface sediment samples were taken. In several zones, there were notable differences in the expected roles and architecture of the bacterial communities. The disturbed zone had the highest concentration of firmicutes, indicating the effects of human activity (Su et al., 2018).

In the Gulf of Finland, the easternmost sub-basin of the Baltic Sea, ribosomal gene segments sequenced from the top sediment layer at two coastal sites in southern Finland in the spring, summer, and late fall over two consecutive years helped scientists understand how the bacterial population responds to the seasonal fluctuations. The dominating taxa were associated with sulfate reducers and organoheterotrophs, and the presence or absence of organic materials in the surface sediment was associated with differences in community structure. Of all the groups, *proteobacteria* were the most varied and prolific. The majority of the species found in the spring samples were *Actinobacteria*, which may have originated in fresh water and were associated with humic carbon. An increase in readings linked to heterotrophic bacteria, such as *Bacteroidetes*, which consume labile organic materials from spring bloom, was seen in summer populations. Taxa characteristics of autumn samples were associated with bacteria feeding on organic debris floating from the phytal zone and with *Cyanobacteria* and other bloom-forming bacteria from the water layer above (Vetterli et al., 2015).

In a study conducted in the coastal regions of Bushehr along the Persian Gulf, the average concentrations of bacterial indicators, such as total and fecal coliform, were 150.87 and 1238.13 MPN/100 ml, respectively. Indicator bacterial concentrations were greater in muddy sediments than in sandy ones. According to the study's findings, bacterial indicators' concentration levels dropped with depth (Karbadehi et al., 2017). Using high-throughput

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

Illumina-based sequencing, the classification of the bacterial population in the surface sediments of the South Eastern Arabian Sea was evaluated. In every station, the predominant phylum found was protobacteria. Additional taxa that were found in large quantities were Nitrospirae, Gemmatimonadetes, Bacteroidetes, Actinobacteria, Acidobacteria, Chloroflexi, and Spirochaetes (Vipindas *et al.*, 2020).

The Alang-Sosiya shipbreaking yard in Bhavnagar, Dwarka, and Kachchigadh (Shivrajpur) sites were selected for Illumina MiSeq next-generation sequencing for comprehensive and comparative research of the bacterial communities and their functional potential of the pure and polluted marine sediments. In every research site, *Proteobacteria* was the predominant phylum. *Actinobacteria*, *Bacteroidetes*, *Planctomycetes*, *Nitrospirae*, *Verrucomicrobia*, *Cyanobacteria*, *Tenericutes*, and *Chlorobi* were among the other phyla. It's interesting to note that around 50% of genera fall into the unclassified category. *Acinetobacter*, *Bacillus*, *Pseudomona*, *Idiomarina*, *Thalassospira*, *Marinobacter*, *Halomonas*, *Planctomyces*, *Psychrobacter*, and *Vogesella* were determined to be the major genera (Raiyani & Singh, 2023).

Through high-throughput 16S rRNA gene sequencing, the fundamental bacterial community composition linked with aquatic sediments of the freshwater, mangrove, and marine ecosystems of a coastal area on the Southwest coast of India (Mangalore, Karnataka) has been examined. Freshwater and marine habitats have larger abundances of phyla Planctomyces and Proteobacteria, which are known to play a vital role in the nitrogen cycle and improve the global nitrogen bioavailability in aquatic ecosystems, according to the V3–V4 hypervariable areas of 16S rRNA gene analysis (Ghate *et al.*, 2021).

Understanding how bacterial populations in the natural environment react to human activity is one of the main goals of contemporary ecology. The effects of marine pollution, particularly those involving heavy metals (HMs), have drawn more attention in recent years. Nevertheless, little is known about how bacterial populations in India's coastal sediments react to HMs. The microbial population in India's southern coastline area was the subject of 16S rRNA gene amplicon sequencing. In the highly polluted area, the proportion of bacterial groups was greater for *Actinobacteria*, *Betaproteobacteria*, and *Gammaproteobacteria*, but lower for *Alphaproteobacteria* and *Flavobacteria*. Also, well-known metal-resistant bacterial species

Gosai., H., G. (2024). Assessment of pollution load of coastal mudflats along the western bank of Gulf of Khambhat with special reference to microbial community structure as bioindicator.

including *Arthrobacter* and *Ralstonia* dominated the samples from the severely polluted region (Rajeev *et al.*, 2021).

The goal of the study was to precisely characterize the makeup of the bacterial community in marine sediments from several coastal locations in Palk Bay and the Gulf of Mannar which are well-known for being popular destinations for tourists. Denaturing Gradient Gel Electrophoresis (DGGE), a commonly used fingerprinting technique, based on the 16S rRNA gene was used to analyze the bacterial richness in various maritime sediments. Proteobacteria was the most prevalent phylum found in the marine sediment samples, followed by *Actinobacteria*, *Cyanobacteria*, *Firmicutes*, *Bacteroidetes*, and *Acidobacteria*. *Thioalkalivibrio* sp. was found to be worldwide in all of the marine sediments. The abundant band's sequencing indicates that *Vibrio* sp. are present in all maritime sediments (Aravindraja *et al.*, 2022).