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Evaluation of Coastal Sediments for Heavy Metal Contamination, Bhavnagar Coast, Gulf of Khambhat, Gujarat, India

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ABSTRACT

This research examined heavy metals distribution and potential environmental impact in seven locations along the Bhavnagar coast in Gujarat, India. The study used several analyses, including hierarchical cluster analysis (HCA), principal component analysis (PCA), and correlation analysis to investigate the harmful heavy metals present in the area. To evaluate the possible risk of Cd, Pb, Cr, Zn, Co, Cu, Ni, Mn, and Fe to the marine environment, pollution indices such as contamination factors (C_f), enrichment factor (E_f), geo-accumulation index (I_{geo}), ecological risk factor (E_r), ecological risk index (RI) and sediment quality guidelines (SQGs) applied. Based on the results, the mean concentration of heavy metals was ranked in the following order (mg/kg): Fe (561.4) > Mn (58.9) > Cr (42) > Zn (12.5) > Pb (8.2) > Ni (7) > Cu (5.2) > Co (2.7) > Cd (.3). Compared to the pre-monsoon and post-monsoon seasons, the results showed a diluting impact on heavy metal concentrations during the monsoon season. The spatial distribution of the heavy metals indicated that the geogenic source and anthropogenic source were the primary contributors to pollution in the studied region. Principal component analysis suggests that Cd, Pb, Co and Cr may have come from shipbreaking activities, municipal discharge and industrial operations. C_f, $I_{geo,}$ and E_f demonstrated no pollution to moderate pollution, with a maximum contribution of Cd, and the coastal sediment poses a minimal ecological risk for all heavy metals investigated. Shipbreaking, urban runoff, salt-marine, and agricultural runoff release toxic metals into the coastal environment. In conclusion, the information obtained from this geochemical characterization could be valuable to policymakers and stakeholders in developing effective management measures for the Bhavnagar coastal region, Gulf of Khambhat, Gujarat, India.

KEYWORDS

Gulf of Khambhat; geochemical characterization; heavy metal contamination; pollution indices; shipbreaking activity

1. Introduction

The significance of environmental assessment studies regarding potential heavy metal contamination cannot be overstated. Heavy metals play a crucial role in the survival of all organisms. Metals such as copper (Cu), zinc (Zn), cobalt (Co), nickel (Ni), chromium (Cr), manganese (Mn), and cadmium (Cd) are necessary for completing metabolic processes within living organisms, as long as their intake remains within safe limits. However, the

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RESEARCH

Evaluation of Surface Water from the Western Coast Bhavnagar, Gulf of Khambhat, Gujarat, India

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Abstract
The current study focuses on seasonal variations in coastal water along the Bhavnagar coast, Gulf of Khambhat, Gujarat, India, during three consecutive seasons (pre–monsoon, monsoon, and post–monsoon). The coastal water samples were collected from seven different locations (Ghogha, Kuda, Mithivirdi, Sosiya, Alang, Sartanpar, and Gopnath). In the designated research region, coastal water samples were collected and evaluated for water physico–chemical characteristics and heavy metals. As a result, sea surface temperature, pH, conductivity, total dissolved solids (TDS), total suspended solids (TSS), total hardness (TH), calcium hardness (Ca^{+2}), chloride (Cl^{-}), salinity, dissolved oxygen (DO), 5th –day biochemical oxygen demand (BOD), chemical oxygen demand (COD) and distribution of dissolved heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn) were investigated at Bhavnagar coast, Gulf of Khambhat. The multivariate statistical analysis indicates that temperature, DO, BOD, COD, Cr, Co, Mn, and Fe, the natural and anthropogenic condition affects the water parameter and dissolved heavy metal. The outcome revealed a dilution effect in physico–chemical parameters and dissolved heavy metal during the monsoon season. The results indicate that anthropogenic disturbances and the growth of a range of activities with increasing point and non–point rainfall poured directly into coastal regions affect coastal water. As a result, the current study's findings may be useful to government authorities trying to safeguard the long–term sustainability of the Gulf of Khambhat.

Keywords Anthropogenic activity · Coastal water pollution · Gulf of Khambhat · Heavy metal · Hydrochemistry

Introduction

The interfaces between the land and the water are called coastal regions, and they are home to significant ecosystems and infrastructure. Around 40% of mankind lives within 100 km of coastal areas (Xiong et al. 2023). Coastal regions (including estuaries and deltas) are extremely complex settings with different hydrodynamic and bio-geomorphological contexts, as well as significant socioeconomic and ecological issues. These systems are among the most impacted by human influence as a result of urbanization and port operations, as well as industrial and tourism activities. Climate change has a direct influence on sea level, storm surge frequency and severity, and the recurrence of coastal river floods (Laignel et al. 2023). India has a coastline that stretches for over 8000 km, with nine coastal states, 60 districts, and two main island groupings where fishing provides a living for many Indian populations (Senapati and Gupta 2014). India, being a developing country, is rapidly industrializing and expanding economically. As a result, the country is dealing with climate change and pollution of the marine environment, posing health risks to marine biota and humans. Out of the nine coastal states in India, Gujarat possesses the longest coastline (about one-fifth of the country's total length), with 49 ports and businesses that support peoples livelihoods including the automotive, energy, chemical, and pharmaceutical sectors (MM&FICCI 2019; Rabari et al. 2022).

Coastal water contains more marine species than open ocean water. Water characteristic in coastal areas is an important component of marine life and its surroundings (Gray 1997; Zenati et al. 2023). Humans have a substantial detrimental

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MINI REVIEW

Lacunae of Microbial Study along the Bhavnagar Coast

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Abstract

Soil microorganisms account for a significant amount of Earth's biodiversity and play an important role in biogeochemical cycles (BGC) and ecosystem function. Understanding the tremendous diversity of the soil environment's complex, microbial population is a challenge. Soil bacteria play an important role in organic matter decomposition, mineral nutrient release, and nutrient cycle. Microorganisms and their microbial activity are also important markers of soil health and can be used as bioindicators to measure pollution levels. Soil microbial diversity has been the subject of extensive research. Human influence is felt along the Bhavnagar coast of Gujarat, India, a region characterized by anthropogenic activity such as coastal industries and a ship-breaking yard, sand extraction, tourism, and ferry service. This review focuses on microbiological investigations undertaken along the Bhavnagar coast, that used reliable identification techniques such as 16S rRNA gene sequencing, the Biolog^{TM} microtitre plate methodology, extensive biochemical assays, and other methodologies. The microbial communities of the Bhavnagar coast have received relatively limited attention thus far, necessitating further research in unexplored areas.

Keywords: 16s rRNA sequencing, Bhavnagar coast, Gulf of Khambhat, Microbial diversity, Soil microorganism.

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Introduction

The anthropogenic inputs affect the presence of microorganisms present in the soil. Considering the enormous scale of the microbial population and the wide diversity of species found in this natural habitat, studying soil is a difficult task for microbiologists (Richter and Markewitz, 1995). Soil is a common substrate found across the world's terrestrial ecosystem. It is a complex mixture of flora, fauna, microbiological life forms, and finely divided mineral elements. Microorganisms not only provide critical ecological tasks in this complex ecosystem, but they also make up a significant amount of the soil's compositional framework (Stotzky and Pramer, 1972). Soil, often known as the Earth's biologically active layer, is an organized mixture of organic materials and mineral elements. The interaction of different elements, such as species, climate circumstances, geological processes, and atmospheric chemistry, influences its development. Soil is a filtration medium that governs the characteristics and availability of Earth's water resources. It is home to colonies of microorganisms that actively participate in the decomposition of organic materials and the recycling of vital chemical elements within the biosphere. Soil plays an important ecological role as the primary processing unit of the Earth's complex biosphere (Sánchez, 1994).

Soil is the Earth's greatest carbon reservoir, having approximately two times the amount of carbon found in the atmosphere and two to three times the carbon content found in all living organisms (Arias *et al.*, 2005). Soils are a multidimensional system made up of plants and microorganisms that stay within a heterogeneous solid matrix with dynamic fluctuations in chemical and physical properties at the molecular and cellular levels. Understanding soil transformations requires a thorough understanding of both chemical and biological techniques due to the reciprocal interactions between microorganisms and the soil environment. Soil microorganisms have a significant impact on the global dynamics of organic matter, participating in the recycling of organic waste materials through mineralization processes, yielding carbon dioxide (CO_2), water (H_2O), nitrogen (N_2), phosphorus (P), sulphur (S), and other essential nutrients (Bossio *et al.*, 1998). Soil is made up of mineral particles with variable sizes, shapes, and chemical properties, as well as a complex interplay of soil biota and organic molecules in various stages of decomposition. The forming of clay-organic matter complexes and the stability of clay, sand, and silt particles aided by aggregate formation are the essential structural features of the soil matrix. The size spectrum of soil matrix components ranges from 2mm aggregates to fractions of a mm containing microorganisms and colloidal particles. Prokaryotes, the most common living forms, are widely spread throughout the soil environment and can contribute significantly to the overall biomass of the soil ecosystem (Hassink *et al.*, 1993).

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Role of Microorganism

Soil, recognized for its incredible ecological diversity, is home to a diverse community of soil microorganisms that includes fungi, viruses, archaea, protozoa, and bacteria. Collectively, these interacting microbial populations contribute to the complicated ecosystem functioning inside the soil environment (Kuzyakov and Blagodatskaya, 2015). Soil microbial diversity has many characteristics, including species variety, genetic

Chapter

4 Metal Contamination Status in Sediment along the Western Belt of Gulf of Khambhat, Gujarat, India

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ABSTRACT

Heavy metal pollution has been considered a great issue since the beginning of the industrial revolution and still, it is a major ongoing issue all around the world. Heavy metals have compromised the environment's potential to nourish life and preserve its essential qualities. Heavy metals are discharged into the environment by both natural and manmade sources, most notably mining and industrial activities. Almost all industrial operations that generate waste are the potential source of heavy metals in the environment. This review includes the source of heavy metals, how metal pollution enters, occurs, affects the environment, and which phenomenon is responsible for the transport of heavy metals into the environment.

Keywords: Gulf of Khambhat, Heavy Metal, Source, Contamination, Tidal Dynamics, Environmental Impacts.

INTRODUCTION

In the Arabian Sea, the Gulf of Khambhat is a funnel-shaped basin with a total length (140km) and a width (80km) at the southern end that extends across India's west coast (Giardino *et al.*, 2014). From the terrestrial region, a few major and several minor rivers are flowing toward the Gulf of Khambhat and merge by forming estuarine deltas such as Narmada, Tapi, Mahi, Sabarmati, Shetrunji, Ambika, and Purna (Anonymous, 2013). The bottom depth at an upstream section of the Gulf of Khambhat varies from 10-30m (Nayak & Shetye, 2003). The gulf head is altered by the Mahi Sagar stream channel and meandering, with the creation of a sandbank (Malacca Banks) toward the Gulf's left bank (Unnikrishnan, 1999).

Chapter 10
Major Environmental Activism in India: Past and Present

Hardik Giri Gosai, Asha Sharma, and Pradeep Mankodi

1 Introduction

Environmental activism/movements are examples of collective actions conducted by different social groupings. These movements are concerned with preserving and recognizing constitutional and democratic rights that are not specified by law but are extremely important in the daily lives of marginalized populations. These rights include resource control, the preservation of indigenous traditions, and environmental protection to maintain ecological equilibrium. Such concerns are critical to these movements because they have a direct impact on human well-being and quality of life (Nair et al., 2022). In recent years, there has been an enormous rise in public interest in environmental concerns. This may be seen in the considerable growth in conservation group membership and the significant increase in ecologically focused articles published in newspapers. Growing worry about environmental hazards has become a prevalent trend, representing a fashionable part of contemporary life (Koenig, 1975).

As a result of its rapid economic growth, India is today facing rising environmental challenges. However, this expansion has come at a high price in terms of environmental deterioration. Air and water pollution are among the most important environmental issues, as are concerns about diminishing water resources, fast-rising deforestation, and the possible health risks connected with climate change. India's

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Climate Change's Impact on Agricultural Food Production

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Abstract Climate change is also quantified in terms of food insecurity. Due to changing climate, a large proportion of soil is declared as saline soil or acidic soil. Continuously decreasing soil fertility due to extreme climatic conditions is a major factor in food scarcity. Several countries do not have regular access to healthy and safe food for all of their citizens. Concerns have been raised about the rising issue of meeting future food demands. Increasing food production has been and will continue to be a central focus of discussions on how to reduce food scarcity. Negative climate and environmental shifts will add more difficulty in meeting future demand. Several factors, including population increase, access to the food supply, productive land, climate change, accessibility, loss of crop, and water resources are redefining the world's food situation. When these numerous factors are considered together, they have had a significant impact on food production and safety around the world. Weather, temperature, and the environment have long influenced how we cultivate, store, distribute, and sell food. The quality of the soil and water, the presence of insects and illnesses, and other natural elements all have an impact on how much food we can produce and how good it is. In this chapter, we'll look at how variations in the Earth's climate effect food production.

Keywords Climate change · Food security · Green revolution · Modern agriculture

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