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A Comprehensive Review Focusing On The Globally Distributed Dominant Macrobenthic Taxa, With Varying Ecosystems, And The Need For Research In Unexplored Freshwater Sources.

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Abstract
Macrobenthos considered as a backbone for aquatic ecosystems, contributing to sediment dynamics, nutrient cycling, biomonitoring, and food web structure. The review was made by the compilation of 100 peer-reviewed research papers on the macrobenthos for diverse aquatic systems, including Asia, Europe, South Africa, South America, and Australia. To identify the global distribution pattern of dominant macrobenthic taxa that are flourishing in different ecosystem types. Although adequate studies have been done on the coastal and estuarine ecosystems, freshwater ecosystems, especially in high mountain ranges and remote areas, remain understudied.
This review elucidated Polychaeta, Insecta, Gastropoda, Bivalvia, and Oligochaeta as having a telling dominance globally; it is nature due to which their presence and prevalence vary by ecosystem type. revealing the dominance of polychaetes in marine and estuarine ecosystems as per custom, and Insecta (especially aquatic larvae) in freshwater and rivers. while the gastropoda and bivalves thrive in freshwater and brackish habitats. Reflecting not only the local habitat conditions but also serving as sensitive bioindicators for even a slight environmental change.
Most of the research gap is highlighted in the region, such as the Nigol River, Uttarakhand, India—a spring-fed Himalayan river having minimal anthropogenic disturbance, as though it has the significance and potential for unique biodiversity, it remains unexplored in the existing macrobenthic assessment. This attests to the need for focused research in underrepresented freshwater systems.
After evaluation of global data and identification of research voids, this review provides the groundwork that will support the future ecological assessments and broader inclusion for freshwater ecosystems in the face of global biodiversity and conservational frameworks.
Keywords: *Dominant Macrobenthic Taxa, Benthic Invertebrates, Anthropogenic impact, Benthic taxa hotspots, Global distribution.*

INTRODUCTION

Bottom zones of aquatic bodies contain a group of small living organisms that are considered good bio-indicators and can be used to evaluate the quality of water and also indicate the health parameters of aquatic ecosystems; observing their diversity, pattern of distribution, and richness could be a great help for estimating the valuable insights regarding the balance associated with aquatic ecosystems (Kumar Hemwati Nandan et al., 2017). Factors, i.e.,physical, chemical, and biological, regulate the structure of macroinvertebrate diversity. Also, the riparian zones with distinct and specific nature associated with water bodies contribute their effect over the macrobenthic population (Rana et al., 2019). Heavy invasion of non-native species in coastal and inland aquatic bodies is multifariously impacting the native species (Park et al., 2017). Developing countries such as the Philippines are threatening the macrobenthic fauna and megafauna (Joseph et al., n.d.). Anthropogenic influences such as using bottom-fishing gear are heavily impacting the benthic species and their habitat (Clarke et al., 2018). Functional diversity is a measure that regulates the different dimensions of an ecosystem, such as productivity, nutrient cycle, stability, and certain other parameters (Garaffo et al., 2018). Shou et al. (2018) worked on the progressive and spatial distribution of macrobenthos to examine the evolutionary changes with respect to changing aquatic ecology. Macrobenthic communities were used to evaluate the environmental changes (Semwal, Mishra, 2019). (KOŞAL ŞAHİN, ZEYBEK, 2019) did the biomonitoring study of macrobenthic invertebrates for an unexplored stream, Surgu (Malatya, Turkey). Benthic invertebrates aggregate the trace elements present in the substrate according to their functional feeding guilds (FFG) and can provide insights about the status of freshwater settings (Pastorino et al., 2020). Attempted a study to account for the quantity of trace elements such as arsenic, cadmium, lead, and zinc that are present in the tissues of macrobenthos with reference to sediment (Pastorino et al., 2020). Applying the concept of multidimensional diversity to enhance the knowledge regarding the restoration of wetlands (Li et al., 2019). Singh, Sharma (n.d.) monitored the macrobenthos in high-altitude wetlands of the Himalayas, which was never done before. Habitats that come under the estuarine zones are considered very dynamic; after examining one of these habitats, it comes forward that the polychaetes are the dominant subsequent to oligochaetes and amphipods (V, C, n.d.). Lipi et al., (2020) studied macrobenthic diversity on a ship-breaking site and compared it with another non-ship-breaking site. Effiong Jonah, Donald Anyanwu (n.d.) estimated the macrobenthic fauna and their physiochemical properties from the Etim Ekpo River situated in Nigeria, which was an unexplored freshwater source. Processed saltmarsh as an area for investigation and found that it was rich in infaunal and epifaunal invertebrates (Akram Ullah et al., 2020). Seasonal changes regulate the organic matter present in sediment, and that is what shapes the isotopic niche and food web of benthic macroinvertebrates (Szczepanek et al., 2021). Non-native species occupy the areas over the native species due to anthropogenic activities; considering this fact, researchers observed the fouling assemblage of non-native species related to artificial substrate (Giangrande et al., 2021). Faremi et al. (2021) studied the effects of sawmill waste on the quality, sediment, and macrobenthic invertebrates present in the water. An unexplored stream in the Rudraprayag district of Uttarakhand, India, was investigated for its macrobenthic diversity as a baseline for upcoming research (Mamgain et al., 2021). This review will discuss the global distribution pattern of dominant macrobenthic taxa, particularly emphasizing how these benthic organisms occur and vary across different aquatic ecosystem types. By synthesizing findings from a broad range of studies, some selected examples are highlighted in the table (Table 1). This review aims to identify trends associated with biogeography, ecological patterns, and knowledge gaps that will inform future research and conservation strategies.

TABLE 1 | Representative macrobenthic taxa (including phylum to species level) recorded in six selected studies from the literature, illustrating taxonomic diversity across different freshwater habitats.

S.NO	REGION / WATER BODY	Key Genera & Species Identified (with Phylum, Order & Family)	Reference
1.	Rawasan Stream, Garhwal Region	**Phylum: Arthropoda** (Insecta) **Ephemeroptera:** Caenis, Cinygma, Cinygmula, Ephemerella, Ecdyonurus, Baetis **Trichoptera:** (Rhyacophila, Agapetus, Hydropsyche, Chimarra, Glossosoma, Leptocella, Philiopotamus **Plecoptera:** Neoperla, Perla **Coleoptera:** Potamonectus, Psephenus, Hydroporus, Hydrophilus **Phylum: Mollusca Lepidoptera &**	(Kumar Hemwati Nandan et al., 2017)

		Platyhelminthes: Nymphula, Polycelis	
2.	Alaknanda River, Uttarakhand	**Phylum: Arthropoda** (Insecta) **Ephemeroptera:** Heptagenia, Epeorus, Ironodes, Cinygma, Baetis, Platybaetis, Baetiella, Leptophlebia, Thraulodes, Ephemerella, Ephemera, Caenis **Odonata:** Enallagma, Ophiogomphus, Lestes, Aeshna **Plecoptera:** Perla, Togoperla, Isogenus, Isoperla, Capnia, Chloroperla, Peltoperla, Taeniopteryx, Leuctra, Nemoura, Paraperla **Hemiptera:** Plea **Megaloptera:** Corydalus **Coleoptera:** Psephenus, Hydrocyphon, Promoresia, Helophorus, Agabus, Gyrinus, Ochthebius **Trichoptera:** Hydropsyche, Philopotamus, Rhyacophila, Himalopsyche, Glossosoma, Agapetus, Brachycentrus, Limnephilus	(Rana et al., 2019)
3.	Coastal Waters	**Phylum: Porifera:** (1 Sponge - Genus Not Provided) **Phylum: Bryozoa:** (2 Bryozoans - Genus Not Provided) **Phylum: Mollusca:** X. atrata, M. galloprovincialis, X. securis **Phylum: Annelida (Polychaetes):** (1 Polychaete - Genus Not Provided) **Phylum: Arthropoda:** (4 Cirripedes - Genus Not Provided) **Phylum: Chordata (Ascidians):** (4 Ascidians - Genus Not Provided)	(Park et al., 2017)
4.	Apo Reef Natural Park	**Phylum: Echinodermata** Holothuria atra, Holothuria edulis, Holothuria fuscogilva, Pearonothuria graeffei, Thelenota ananas, Thelenota anax, Thelenota rubralineata, Choriaster granulatus, Thromidia catalai, Culcita	(Joseph et al., n.d.)

		novaeguineae **Phylum: Mollusca** Tridacna crocea, Tridacna maxima **Phylum: Porifera** Xetospongia sp.	
5.	Poole Harbour	**Phylum: Mollusca** Peringia ulvae **Phylum: Annelida (Polychaetes):** H. diversicolor, Tubificoides spp., A. tenuis, A. marioni, Streblospio shrubsolii	(Clarke et al., 2018)
6.	Polluted Coastal Areas	**Phylum: Annelida (Polychaetes):** Boccardia proboscidea, Syllis gracilis, Syllis prolixa **Phylum: Mollusca (Bivalvia & Gastropoda):** Brachidontes rodriguezii, Siphonaria lessonii	(Garaffo et al., 2018)

Globally distributed dominant macrobenthic taxa

To find any possible distribution pattern of dominant macrobenthic taxa across the globe, a map was created using the QGIS software (Fig. 1) with accurate latitude and longitude coordinates as mentioned in the compiled literature from 100 peer-reviewed research papers. Describing the Asian continent as the concentrated zone of macrobenthic research, followed by Europe, Africa, and South America. Unavailability of data for the Australian and North American continents, potentially a literature gap or underrepresentation within the selected sources. The map reveals studies conducted in India, in locations such as Rawasan Stream (Kumar Hemwati Nandan et al., 2017), Alaknanda River (Rana et al., 2019), Hiyunl Basin (Semwal, Mishra, 2019), Dodi Tal (Singh, Sharma, n.d.), Cochin Port (V, C, n.d.), Rudraprayag (Mamgain et al., 2021), Ganga River (Roy et al., 2022), Paradip Port (Noyel, Desai, n.d.), Gulf of Khambhat (Sahu, Haldar, 2022), Ichamati River (Basu et al., 2018), Beas River (Jamwal et al., n.d.), Cochin Estuary (Rehitha et al., 2017), and Estuarine Part of Subhadra River (Dash et al., 2020), while taking about the China, the study location are, Yellow sea (Shou et al., 2018), Yellow River Delta

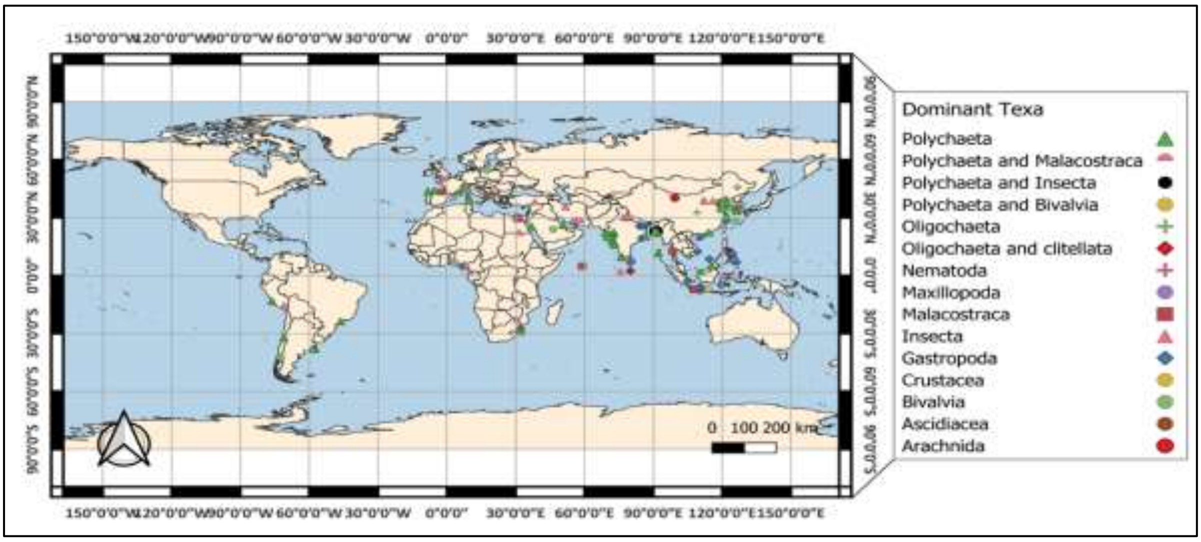

FIGURE 1 | Macrobenthic Diversity Across the Globe.

Wetland (Li et al., 2019), Baiyangdian Lake (Fu et al., 2022), Majiagou Urban River (Zhang et al., 2023), Xiaoquing Estuary (Liu et al., 2023), Northern Sea Yantai (Li et al., 2022), Ximen Island (Q. Wang et al., 2021b), Dongzhaigang Bay (Guo et al., 2024), Heihe River (Y. Wang et al., 2021), Cangnan Sea (Han et al., 2025), Maoyan Island (Q. Wang et al., 2021a), Liandao Beach (Wu et al., 2020), Hangzhou Bay (Jia et al., 2022), Bohai Sea (Li et al., 2020), and Niushan Island (Tian et al., 2023), studies in Bangladesh (Akram Ullah et al., 2020; Haque et al., 2021; Hossain, Hossain, 2021; Hossain et al., 2018; Lipi et al., 2020; Matin et al., 2018; Rahman et al., 2021; Tania et al., 2020), and Indonesia (Arfan et al., 2024; Naqsyabandi et al., 2018; Putro et al., 2022; Rozirwan et al., 2021; Suciyono et al., 2024). The study locations across Europe demonstrate moderate involvement in comparison to Asian studies, particularly in Italy (Gabetti et al., 2024; Giangrande et al., 2021; Pastorino et al., 2020), along with Spain (Carreira-Flores et al., 2021; Rodil, Lastra, 2022), Turkey (KOŞAL ŞAHİN, ZEYBEK, 2019), and Poland (Szczepanek et al., 2021). Moving forward to Africa represents fewer studies, majorly in Nigeria (Dirisu, Edwin-Wosu, 2022; Effiong Jonah, Donald Anyanwu, n.d.; Faremi et al., 2021), South Africa (J. I. Izegaegbe et al., 2020; Joshua Idowu Izegaegbe et al., 2020; Munyai et al., 2024), and Egypt (Bendary, Ibrahim, 2021; Khalil et al., 2017; Wahab et al., 2018). Further, South America has the least documented study sites, notably in Brazil (Abessa et al., 2019; Delgado et al., 2023), Argentina (Garaffo et al., 2018; Verónica et al., 2025), Chile (Soto et al., 2017; Villalobos et al., 2021), Guyana (Ram et al., 2025), and Peru (Chunga-Llauce et al., 2023). Despite Asia being ecologically rich and diverse, it lacks the literature in context to West Asia. Regional variation of dominant macrobenthic taxa is clearly evident. Polychaetes have been heavily reported in temperate and subtropical zones, i.e.,locations like China, India, and the Mediterranean (Giangrande et al., 2021; Shou et al., 2018; V, C, n.d.). By observing carefully towards the western regions and coastal zones (i.e.,the Gujarat, Maharashtra, Goa, and Kerala coasts) of India. It clearly points out the prominent presence of polychaetes, which were represented by light green triangles for visualization in the given map. Clustered dominance of polychaetes is also perceptible in the western parts of Bangladesh. In Southeast Asia the dominance of gastropoda is visible (Fig. 1). Notably, India's northern regions, particularly Uttarakhand (Kumar Hemwati Nandan et al., 2017; Mamgain et al., 2021; Rana et al., 2019; Semwal, Mishra, 2019), have a dominance of Insecta, an indication of unique ecological conditions in the high-altitude ecosystems of mountainous streams. Insecta taxa visualized in the map are represented by light pink triangles for map visualization. Which clearly distinguishes them from other dominant taxa. Areas that cover the eastern belt of India. Like Uttar Pradesh and West Bengal, having the presence of gastropoda taxa in a clustered way, symbolizing gastropoda as a blue diamond for visualization in the map. The supremacy of gastropods in these regions may be due to the climatic conditions, freshwater system, and the physicochemical properties that are favorable for their proliferation. In the Noakhali coast of Bangladesh, the overlapping dominance of Polychaetes and Insecta taxa was notable (Akram Ullah et al., 2020), which is represented by the black circle in the given map. This dual dominance may be due to the region of the estuarine zone varying substrate and salinity levels. Apparently, in the context of literature studied, South America shows relatively few studies, especially in locations like Poole Harbour, UK; Code River, Yogyakarta, Indonesia; Valparaiso Bay, central coast of Peru; Santos Estuarine System, Brazil; and Guyana's coastline, South America (Abessa et al., 2019; Chunga-Llauce et al., 2023; Delgado et al., 2023; Garaffo et al., 2018; Ram et al., 2025; Soto et al., 2017; Verónica et al., 2025; Villalobos et al., 2021). These emerging patterns for coastal and estuarine systems show the significance of polychaete taxa. Malacostraca, less dominant in terms of global scale, is represented by a brown square in the map for visualization, showing their dominance in a scattered way, not making clusters in the whole map, mostly visible in North Asia, then in Africa, and lastly in Europe. No trace of them can be seen in South America, North America, and Australia in the studied literature. The global locations where dominance of malacostraca can be observed are Mhlathuze Estuary; Lake Qaroun, Egypt; Guyana's coastline, South America; Kan Maw Island, Myanmar; and the northern margin of Spain (J. I. Izegaegbe et al., 2020; Khalil et al., 2017; Lwin, 2020; Ram et al., 2025; Rodil, Lastra, 2022). These signs point towards the specific niche and habitat conditions that favor their flourishing. A variety of taxonomic distributions exists throughout South Asia, East Asia, and Southeast Asia, describing the cluster dominance of polychaetes, gastropoda, and malacostraca in patches, and the presence of other macrobenthic taxa evinces the complex dynamic of these benthic ecosystems. Across the Yellow Sea regions in eastern China as well as the nearby estuarine areas, Polychaeta taxa demonstrate continuous dominance, indicating their successful existence within marine and brackish environments. The research sites identified under references (Dong et al., 2023; Han et al., 2025; Li et al., 2022, 2020; Liu et al., 2023; Shou et al., 2018) show this pattern by displaying dense polychaete communities due to the consistent benthic substrate and tidal patterns of the area. Interestingly, Bivalvia taxa also emerge with localized dominance in certain pockets within these coastal systems—indicating favorable sediment grain sizes and nutrient availability that support filter-feeding molluscs. Though not as widespread as polychaetes, their occurrence adds a layer of diversity to China's macrobenthic landscape. Moreover, some areas of China—particularly freshwater-influenced inland sites such as (Fu et al., 2022; Y. Wang et al., 2021; Zhang et al., 2023)—exhibit a clustered presence of Insecta taxa, reinforcing patterns seen in high-altitude or stream-associated habitats similar to those in northern India. These insect-dominated sites are sparse but ecologically significant. In contrast, Oligochaeta taxa, although present at scattered sites across the Chinese region (e.g., (Chen et al., 2025; Zhang et al., 2023)), do not exhibit any clear spatial clustering. Across all the analyzed sites worldwide, Oligochaeta exhibit a dispersed distribution since no specific region demonstrates high dominance of these taxa. This indicates that Oligochaeta shows versatility in their ecological niches yet fails to become leading groups in benthic communities. A complex global biogeographic pattern emerges from the macrobenthic taxonomic distribution because Polychaeta and Insecta group together, but Oligochaeta distributes widely. The identified taxonomic as well as spatial patterns offer researchers unique opportunities to study ecological matters on a worldwide scale. Finding the dominant macrobenthic taxa for different biogeographic regions, considering species-specific relation and tolerance with phycochemical properties and their matter decomposition skills, may enable us to develop techniques for sustainable bioremediation methods. The integrated comprehension enables potential water body restoration by fostering the conservation or promotion of natural ecological purification species, which simultaneously supports water quality goals through biodiversity preservation.

Dominant macrobenthic taxa with varying ecosystems The distribution of dominant macrobenthic taxa across different aquatic ecosystems varies significantly, as highlighted by our literature review and

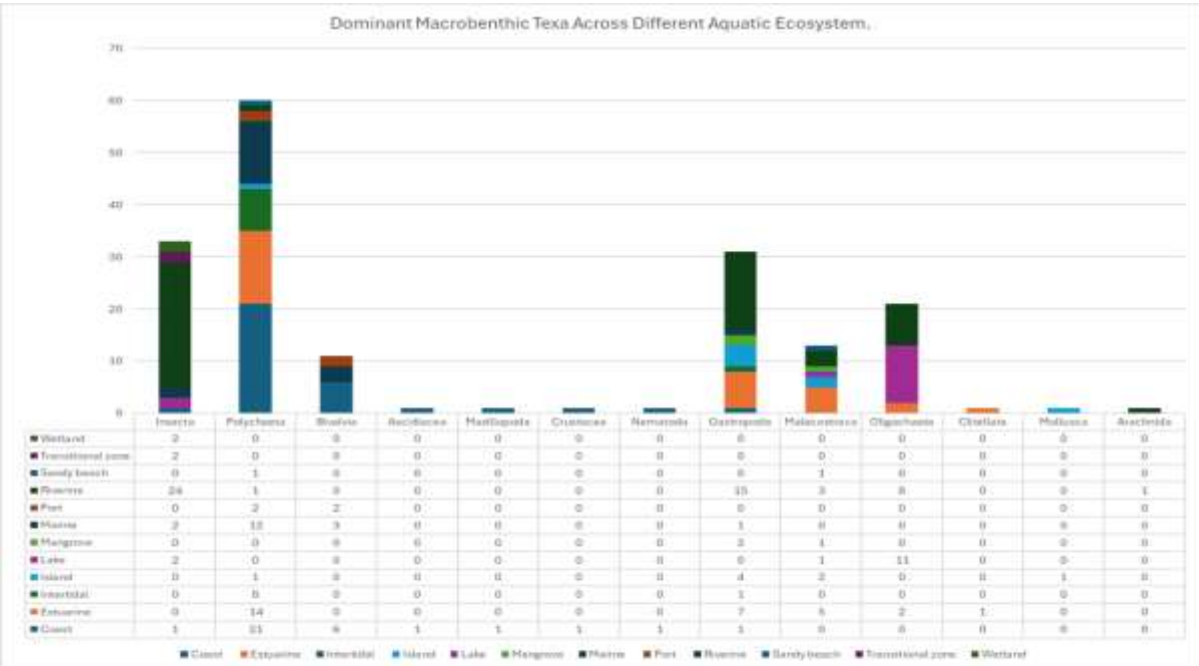

FIGURE 2 | Graphical Representation of Dominant Macrobentic taxa in varying ecosystem.

compiled dataset. Among all taxa, Insecta shows pronounced dominance in riverine ecosystems, particularly in the northern parts of India such as Uttarakhand, where the cold and fast-flowing streams provide ideal habitats for aquatic insects (Kamboj, Kamboj, 2021; Kumar Hemwati Nandan et al., 2017; Munyai et al., 2024). This is also supported by the dataset where Insecta shows its highest occurrence (24 instances) in riverine systems, with only sporadic presence in lakes, wetlands, transitional zones, and coastal regions. Polychaeta, known for their adaptability to saline environments, display strong dominance in marine and coastal ecosystems, evident both in the visual map and dataset (21 records from the coast and 12 from marine systems) (Han et al., 2025; Joshua Idowu Izegaegbe et al., 2020; Naser, 2022). Bivalvia taxa, while less widespread, are primarily found in coastal and marine areas, suggesting a preference for stable saline conditions (Faremi et al., 2021; Villalobos et al., 2021). Similarly, Ascidiacea are exclusively recorded along coastlines, making their presence highly localized and limited globally (Giangrande et al., 2021). Interestingly, the presence of Insecta in some parts of China, particularly in clustered form, as well as scattered occurrences of Oligochaeta, suggests that while these taxa exist in diverse ecosystems, their global clustering is limited. Gastropoda shows notable dominance in riverine systems (15 records) and appears sporadically in estuarine and island ecosystems. Their ecological presence may be tied to nutrient-rich freshwater systems and moderate temperatures (Liang, Ma, 2025; Roy et al., 2022; Zvonareva et al., 2020). Malacostraca appears in small clusters in mangrove-influenced and riverine environments, especially in parts of Southeast Asia, indicating specialized niches (Pratiwi et al., 2024; Ram et al., 2025). Lesser-documented groups like Maxillopoda, Crustacea, and Nematoda also show localized dominance, with their primary presence confined to coastal regions. Despite being globally sparse, their roles in specific coastal food webs may be ecologically important (Ferdiansyah, Ali, 2022; Hossain, Hossain, 2021; Sbrocca et al., 2021). Oligochaeta, a group generally associated with freshwater sediment environments, is most prominently found in lake systems (11 records), revealing a strong habitat association with calmer, nutrient-rich lentic ecosystems (Chen et al., 2025; Pastorino et al., 2020). However, unlike Insecta, their presence is not observed in clustered global patterns. The compiled dataset indicates limited occurrences of Clitellata as well as Mollusca and Arachnida because either underreporting exists or these taxa truly have restricted distributions in macrobenthic habitats (Calle et al., 2018; Li et al., 2020; Y. Wang et al., 2021). The dominance structure of freshwater ecosystems corresponds to Insecta while Polychaeta controls marine and brackish areas and Gastropoda together with Oligochaeta and Malacostraca maintain distinct regulatory roles in each water body. Each taxon maintains vital ecological functions, which should be assessed not only via occurrences but also through their operational roles in aquatic systems. The burrowing behaviours along with filter-feeding techniques of Polychaeta and Bivalvia taxa help mix sediment while purifying water in marine coastal areas (Carreira-Flores et al., 2021; Giampaoletti et al., 2023; Khalil et al., 2017; Liang et al., 2024). This ecological service is particularly valuable in estuarine and deltaic regions, where organic loads are often high and natural bioturbation by benthic fauna becomes essential for maintaining ecological balance. Similarly, Gastropoda, often dominant in riverine and estuarine zones, play a vital role in grazing periphyton and detritus, thereby influencing nutrient cycling and energy transfer across trophic levels (Dash et al., 2020; Hettige et al., 2024; Roy et al., 2022). Interestingly, the scattered presence of Malacostraca in mangrove zones may hint at specialized adaptive strategies, potentially linked to the complex structural habitat provided by mangrove root systems. These areas serve as vital nursery grounds for many macrobenthic organisms and support a unique trophic web (Ram et al., 2025). Environmental limitations and habitat specializations probably restrict the dominance of Ascidiacea Maxillopoda and Nematoda to coastal habitats because tidal patterns and sediment type together with salinity gradients define which organisms can survive there. The tolerance of Oligochaeta groups to salinity changes and energetic oceanic conditions seems low based on their absence from dynamic coastal areas and estuarine ecosystems (Chen et al., 2025; Haque et al., 2021; Pastorino et al., 2020; Tania et al., 2020; Zhang et al., 2023). The near absence of globally clustered patterns for this group also indicates a more scattered and possibly under-sampled distribution. In contrast, the widespread dominance of Insecta in riverine networks across multiple biogeographic zones reinforces their robustness and adaptability in flowing freshwater habitats. Ultimately, the observed distribution patterns of these dominant macrobenthic taxa—when interpreted through the lens of ecosystem-specific dynamics—underscore a complex yet coherent structure of ecological specialization. This detailed understanding not only enhances our knowledge of benthic biodiversity but also sets the groundwork for identifying potential bioindicators for water quality monitoring. Such taxa, depending on their tolerance or sensitivity to pollutants, can serve as natural sentinels for assessing aquatic ecosystem health, which is critical for conservation and management efforts on a global scale (Alaei, 2025; Bay et al., n.d.; Chunga-Llauce et al., 2023; Delgado et al., 2023; Gabetti et al., 2024; Liang et al., 2025; Lourido et al., 2023). Furthermore, the localized occurrence of taxa such as Maxillopoda, Crustacea, and Nematoda along coastal ecosystems, as shown in the dataset and supported by literature, highlights a trend of ecological specialization likely driven by salinity gradients, sediment characteristics, and trophic interactions in these regions (Ferdiansyah, Ali, 2022; Hossain, Hossain, 2021; Sbrocca et al., 2021). Though their overall presence remains limited, these taxa may play crucial roles in microhabitat-level processes, especially in nutrient cycling and as prey items for higher trophic organisms. Notably, the data shows Maxillopoda, Crustacea, and Nematoda exclusively in coastal environments, indicating that their spatial distribution is tightly linked to such dynamic and saline interfaces (Ferdiansyah, Ali, 2022; Hossain, Hossain, 2021; Sbrocca et al., 2021). Moreover, while Ascidiacea taxa were rarely encountered globally, their confinement to coastal ecosystems suggests a narrow ecological amplitude or underrepresentation in other systems due to limited sampling efforts. The dataset confirms this with a singular record of Ascidiacea in the coastal zone, reaffirming their restricted habitat range (Giangrande et al., 2021). In contrast, Oligochaeta exhibit substantial dominance in lake systems—recorded 11 times—emphasizing their affinity for still, organic-rich freshwater sediments (Chen et al., 2025; Pastorino et al., 2020). Their absence in more turbulent or saline systems might be attributed to physiological constraints or competition with other benthic taxa more it is clear from both the compiled dataset and literature review that Polychaeta emerges as the most dominant macrobenthic taxon globally, particularly in marine and coastal ecosystems. Following this, Insecta holds a significant presence, especially in riverine systems, showcasing their adaptability to freshwater currents. Gastropoda ranks third in dominance, most notably in riverine and estuarine environments, while Oligochaeta follows, showing strong associations with lentic systems like lakes. Malacostraca, although present in fewer instances, displays ecological significance in mangrove and riverine habitats. Other groups like Bivalvia and Ascidiacea demonstrate more restricted distributions, mainly in coastal and marine ecosystems.

Taxa such as Maxillopoda, Crustacea, and Nematoda are rarely reported and are generally confined to specific niches, mostly along coasts. Even rarer are Clitellata, Mollusca, and Arachnida, whose appearances are sparse in both global datasets and published studies. An important insight from the literature review is the recurring issue of taxonomic resolution: several studies mention dominance at the phylum level but do not specify the dominant classes or orders within those phyla. This limitation is particularly evident for Nematoda and Mollusca, where phylum-level dominance is often reported without clarifying which specific classes (such as Gastropoda or Bivalvia in Mollusca) are most prevalent. This lack of finer taxonomic detail underscores the pressing need for improved resolution in macrobenthic biodiversity assessments to enhance ecological understanding and guide more effective environmental management strategies (Dandan, Diocton, 2019; J. I. Izegaegbe et al., 2020; Khalil et al., 2017; Soto et al., 2017; Verónica et al., 2025). This observed variation in dominance and the gaps in taxonomic specificity not only reflect ecological preferences and environmental conditions across different aquatic ecosystems but also highlight the critical need for standardized and detailed taxonomic reporting in macrobenthic research. Addressing these gaps would significantly enhance our understanding of benthic biodiversity patterns and improve the utility of these taxa as indicators of ecosystem health and water quality (Dong et al., 2023; Kosari et al., 2021; Liu et al., 2019; Wahab et al., 2018; Wang et al., 2020).

DISCUSSION

The dataset shows benthic communities to be structurally complex because it contains multiple taxa from phyla such as Mollusca, Arthropoda, Annelida, Nematoda, and Chordata. Polychaeta, together with Gastropods, Bivalves, Insecta, and Oligochaeta, were some dominant classes that appear regularly across both coastal and freshwater areas because they can thrive across different environmental conditions as well as different types of substrates. Two groups within Molluscs referred to as Bivalvia and Gastropoda live mostly in soft sediments, where they play a vital role in sediment cycling and water purification functions (Wang et al., 2017). Gastropods, which mainly inhabit periphytic environments, consume biofilms while redirecting nutrients throughout the ecosystem. These groups actively inhabit diverse environmental areas throughout the riverine, along with a few estuarine and coastal systems, displaying their ability to adapt to different habitats. Aquatic insects and crustaceans within arthropods constitute significantly large parts of macrobenthic fauna. The aquatic insect population composed of chironomids, mayflies, and caddisflies exists throughout freshwater environments where they function both in organic matter breakdown and as prey items for upper trophic stage organisms (Abessa et al., 2019; Jones et al., 2024; Kokesh et al., 2022). Researchers have discovered that polychaetes dominate marine and estuarine environments while demonstrating stunning morphological together with functional diverse patterns (Al-Asif et al., 2020; Bendary, Ibrahim, 2021; Lipi et al., 2020; Rodil, Lastra, 2022; Salang, Macusi, 2020; Vijapure et al., 2019). Freshwater sediments act as a preferred habitat for oligochaetes while they remain uncommon. The marine strata are sometimes dominated by the Crustacean classes Malacostraca and Maxillopoda. Polychaeta and Oligochaeta among annelids help increase sediment disturbance and process organic substances in marine habitats. These segmented worms (polychaetes) control marine and estuarine habitats and show significant differences between their forms as well as their capabilities (Coayla-P et al., 2022; Dirisu, Edwin-Wosu, 2022; Lwin, 2020; Nosad et al., 2021). The class Nematoda, alongside Ascidiacea and Clitellata, remains an uncommon subject during wide-ranging surveys. Modern knowledge about these taxa exists in established marine and estuarine research settings, yet many freshwater ecosystems, including the ones in tropical and subtropical areas, still lack extensive research. Lakes, wetlands, streams, and groundwater-fed springs in many parts of Asia, Africa, and South America remain poorly sampled and likely harbor unique or endemic macrobenthic taxa that have yet to be documented. These habitats are often subjected to rapid environmental changes from urbanization, agriculture, and climate impacts, making the need for timely biodiversity assessments even more urgent (Liang et al., 2025; Thoms et al., 2018). Furthermore, the taxonomic resolution f many surveys is limited, often stopping at the family or genus level, which restricts the accuracy of ecological interpretation. There is a critical need for integrative taxonomic approaches that combine morphological identification with molecular tools such as DNA barcoding and metabarcoding to capture cryptic diversity and uncover previously unrecognized speciesv (Delgado et al., 2023; Joydas et al., 2018). In conclusion, by observing the dataset, it affirms the macrobenthic taxa as important ecological bioindicators and ecosystem engineers and contributes to the aquatic food webs. Additionally, this rapid overview displays an overall questionable research distribution between marine environments that receive better scientific attention compared to freshwater environments. Focused sampling, in-depth taxonomic research, and research focused on remote habitats or less explored regions can be a great step toward correcting this imbalance, which will deepen our understanding of global benthic biodiversity and will strengthen our efforts for conservation and management strategies.

RESULTS AND CONCLUSION

The study of macrobenthic communities detected three primary dominant taxa, which included Polychaeta together with Insecta and Gastropoda. Marine annelids called polychaetes were the most abundant organisms found in both estuarine and coastal sediments, where they fundamentally participated in sediment turnover processes and organic matter decomposition. The water quality assessment uses mayfly along with caddisfly and midge aquatic larva populations as indicators, while their biological activities contribute to nutrient cycling in fresh aquatic environments. Freshwater snails, together with marine snails, were present across different substrates where they consumed periphyton while allowing exchange of nutrients. The Nigol River in Uttarakhand functions as a clean Himalayan spring-fed stream that scientists have yet to study, which could host special benthic species. The site has less untouched biological life functions with first-class ecological health and with less human-caused disturbances. Therefore, it provides perfect conditions for launching baseline biodiversity research. The scientific community needs to direct increased focus toward uncharted freshwaters as a remedy for missing knowledge. Understanding macrobenthic diversity in such water bodies serves both scientific and freshwater conservation needs in ecosystems of biodiversity abundance such as the Himalayas.

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