International Journal of Zoology Studies
www.zoologyjournals.com
ISSN: 2455-7269
Received: 39-05-2022, Accepted: 15-06-2022, Published: 30-06-2022
Volume 7, Issue 1, 2022, Page No. 87-95

Diversity status of marine worms of Gir Somanath district of Gujarat state, India

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Abstract
Marine worms play an important role in the environment in marine food chains such as prey, predators, filter feeders, or scavengers and are similarly important to aquatic bioturbators as deposit feeders. Diversity of Marine worms has been studied during December-2019 to December-2020 in the intertidal zone of Gir somnath district of Gujarat state some part like Vadodara dodiya ($20^0$97' 82"62 N, $70^0$25'29"11 E), Aadri ($20^0$95' 91"96 N, $70^0$27'95"85 E), Navapara ($20^0$94' 45"80 N, $70^0$30'10"86 E) and Dari ($20^0$93' 60"26 N, $70^0$31'21"99 E) coast. The field Study was done during Lowtide. Total of 13 species from 7 families were recorded during the field Study. *Eulalia viridis* was found to be highly abundant. Navapara site had highest species Diversity in comparison to other sites. Water quality parameters like Temperature, pH, Salinity and Total Dissolved Solid (TDS) showed in normal range during study period. To assess the difference between the studies sites, specific diversity indices were used.

Keywords: marine worms, aadri coast, water quality parameters, diversity indices

Introduction
The Intertidal zone between high tide and Lowtide, similar to the Door of 6.5 million species that live on land. It is very fertile and has high biodiversity. Gir somnath district coastline, one such piece of coast, 1600 km of coast line of Gujarat state of India (Trivedi and vachhrajani, 2013 Jha, *et al*. 2009). Grow various types of algae because of the rocky and sandy features and especially because of the rocky features. Macrofauna is abundant due to different types of algae. The turbidity is low compared to gulf of Khambhat and it also supports rich biodiversity. Different types of Macrofauna have different types of roles in ecosystem. And marine worms are one of them. Marine worms play an important role in the environment in marine food chains such as prey, predators, filter feeders, or scavengers and are similarly important to aquatic bioturbators as deposit feeders. Marine worms belong to many different phyla, including the Platyhelminthes (flatworms), Nematoda (roundworms), Annelida (segmented worms including tube worms and bristle worms), Chaetognatha (arrow worms), Hemichordata (acorn worms), Phoronida (horseshoe worms), Nemertea (ribbon worms or proboscis worms), Sipunculid worms (peanut worms) and Echiura (Spoon Worms and Innkeeper Worms).
Polychaetes are bristle-bearing segmented worms belonging to phylum Annelida, class Polychaeta. Polychaetes being the most dominant groups in benthic in faunal communities contribute about 80% to the total macro benthic community and their diet include microbial (bacteria, microalgae, protists and fungi), meiobial and organic substance (Shou *et al.*, 2009). information in the World Register of Marine Species, and is found 11,456 the major types of modern polychaetes (1,417 genera and 85 families) have been identified by 835 of the first authors have since 1758. The six polychaete families with the largest number of species have been Syllidae (993 types), Polynoidae (876 species), Nereididae (687 species), Spionidae (612 species, Terebellidae (607 species) and Serpulidae (576 species. (Joko Pamungkas, Christopher J. Glasby, Geoffrey B. Read, Simon P. Wilson & Mark J. Costello, 2019) [33]
Polychaetes form an important component in the marine food chain especially for bottom fish and some mammals as they form an important source of food for demersal fish (parulekar *et al*. 1982; Herman *et al*.2000). Worldwide number of Polychaetes estimated as 8000 species (Bianchi & Morri, 2000; Fredj *etal.*,1992). Platyhelminthes are one of the largest animal phyla after arthropods. The phylum Platyhelminthes comprises dorsoventrally flattened worms commonly known as flatworms (from the Greek *platys*, meaning fl at, and *helminthos*, meaning worm) (Hyman 1951; Rieger *et al*. 1991) [10, 36]. The most intensive work on polyclad diversity, from the Indo-Pacific region, was by (Newman and Cannon (1994, 1995, 1996a, b, 1997, 1998, 2000) [23, 24, 25, 26, 27, 28, 29, 30] Newman and Anderson (1997) [23, 24], Newman and Peter (2002) [32], Newman *et al*. (2003).

Materials and Method

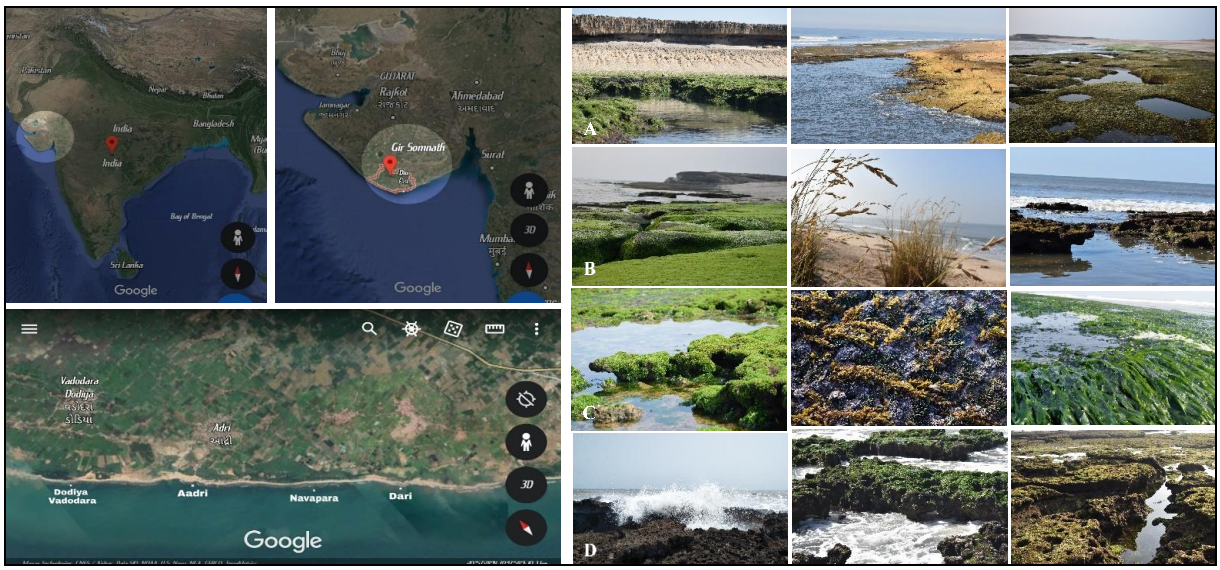


Plate 1: Locations of study sites & Different types of habitat of various study sites: A. Vadodara Dodiya, B. Adri, C. Navapara, and D. Dari**.**

Study Area

Gujarat state is situated at western coast of India with longest coastline about 1600 km with 12 District i.e. kachchh, Devbhumi dwarka, porbandar, gir-somnath, amreli etc. In Gir-somnath district some area (Plate no.1) like Vadodara dodiya ($20^0$97' 82"62 N, $70^0$25'29"11 E), Aadri ($20^0$95' 91"96 N, $70^0$27'95"85 E), Navapara ($20^0$94' 45"80 N, $70^0$30'10"86 E), Dari $20^0$93' 60"26 N, $70^0$31'21"99 E. located on north west edge of near veraval. Coastal area of Vadodara dodiya, Aadri, Navapara, Dari having the mostly type of intertidal habitat rocky, and some are sandy.

Diversity Studies

Extensive photography was done (by Nikon D3500) on site for identification of Marine worm's species. Field study was carried out twice in a month. Marine worms were identified using standard literatures, WoRMS (World Register of Marine Species) and checklist of reported species was prepared. The Identification and study of marine worms were done by the available literature, books, journals, and references.

Physico-Chemical Parameters

Water samples were collected monthly from December-2019 to December-2020.Samples were brought to the laboratory and stored in cleaned, air dried plastic bottles for further water analysis. The air and water temperature were measured using a standard mercury centigrade thermometer. The water pH, total dissolved solid (TDS) and Conductivity were measured by Multi-Parameter PCSTestr-35. The Multi-Parameter PCSTestr- 35 was calibrated with standard buffer chemicals prior to use. The water salinity was measured by using hand refracttometer. The turbidity was measured by Nephelometer CL 52D.

Statistical Analysis

Statistical analysis was done on the basis of the availability of data and calculation was done using different sophisticated statistical tools software.

Diversity Indices

Number of taxa (*S*), Total number of individuals (*n*)

Dominance=1-Simpson index. Ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely). *D=sum((ni/n)2)* where *ni* is number of individuals of taxon *i*.

Simpson index=1-dominance. Measures 'evenness' of the community from 0 to 1. Note the confusion in the literature: Dominance and Simpson indices are often interchanged!

Shannon index (entropy). A diversity index, taking into account the number of individuals as well as number of taxa. Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. *H=-sum ((ni/n)ln(ni/n))*

Buzas and Gibson's evenness = e^H/S

Menhinick's richness index - the ratio of the number of taxa to the square root of sample size.

Margalef's richness index: ***(S-1)/*ln*(n),*** where *S* is the number of taxa, and *n* is the number of individuals.

Equitability: Shannon diversity divided by the logarithm of number of taxa. This measures the evenness with which individuals are divided among the taxa present.

Fisher's alpha - a diversity index, defined implicitly by the formula $S=a*\ln(1+n/a)$ where *S* is number of taxa, *n* is number of individuals and *a* is the Fisher's alpha.

Berger-Parker dominance: simply the number of individuals in the dominant taxon relative to *n*.

Chao1: An estimate of total species richness (Chao 1984). Version without bias correction:

$$SChao1 = S + (n - 1/\,n)\, F^2{}_1 / 2F_2$$

Where *F*1 is the number of singleton species and *F*2 the number of doubleton species.

Result and Discussion

Total of 13 species (Plate-2 and Table-1) belonging to 7 families were found from the coast of Vadodara dodiya, Adri, Navapara and Dari during field work. Taxonomic classification and frequency of species found at the study sites are given in Chart no-1.

Fluctuations in temperature of water and air were measured on the study sites given in Chart No.2. Other water quality parameters *viz*. pH, TDS, Turbidity and salinity are given in Table No.2.

Eulalia viridis was found to be highly abundant. And Navapara site had highest species Diversity in comparison to other sites which is shown in Chart No.3.

Statistical analysis of Diversity indices in past software are given in table no. 3

Plate 2: Diversity of Marine Worms

A. Hermodice sp. **B**. Cirratulus cirratus **C**. Eurythoe complanata **D**. Nereis sp. **E**. Acotylea sp. **F**. Pseudoceros indicus **G**. Pseudoceros susanae **H**. Perinereis sp. **I**. Serpula sp. **J**. Lineus mcintoshii **K**. Eulalia viridis **L.** Unidentified **M**. Amphinome sp. **N**. Unidentified O. lineus sp.

Table 1: classification of marine worms

Phylum	Family	Species
Annelida	*Amphinomidae Lamarck,1818*	*Eurythoe complanata(Pallas,1766)*
		Hermodice sp.
		Amphinome sp.
	Cirratulidae Ryckholt,1851	*Cirratulus cirratus(O.F Muller,1776)*
	Nereididae Blainville,1818	*Nereis sp.*
		Perinereis sp. (Kinberg,1865)
	Phyllodocidae Orsted,1843	*Eulalia viridis (Linnaeus,1767)*
	Serpulidae Rafinesque,1815	*Serpula sp.*
platyhelminthes	Sub order: *Acotylea*	Unidentified
	Pseudocerotidae Lang 1884	*Pseudoceros indicus(Newman & Schupp,2002)*
		Pseudoceros susanae (*Newman & Anderson,1997)*
Nemertea	*Lineidae Sowerby,1806*	*Lineus mcintoshii (Langerhans,1880)*
		Lineus sp.

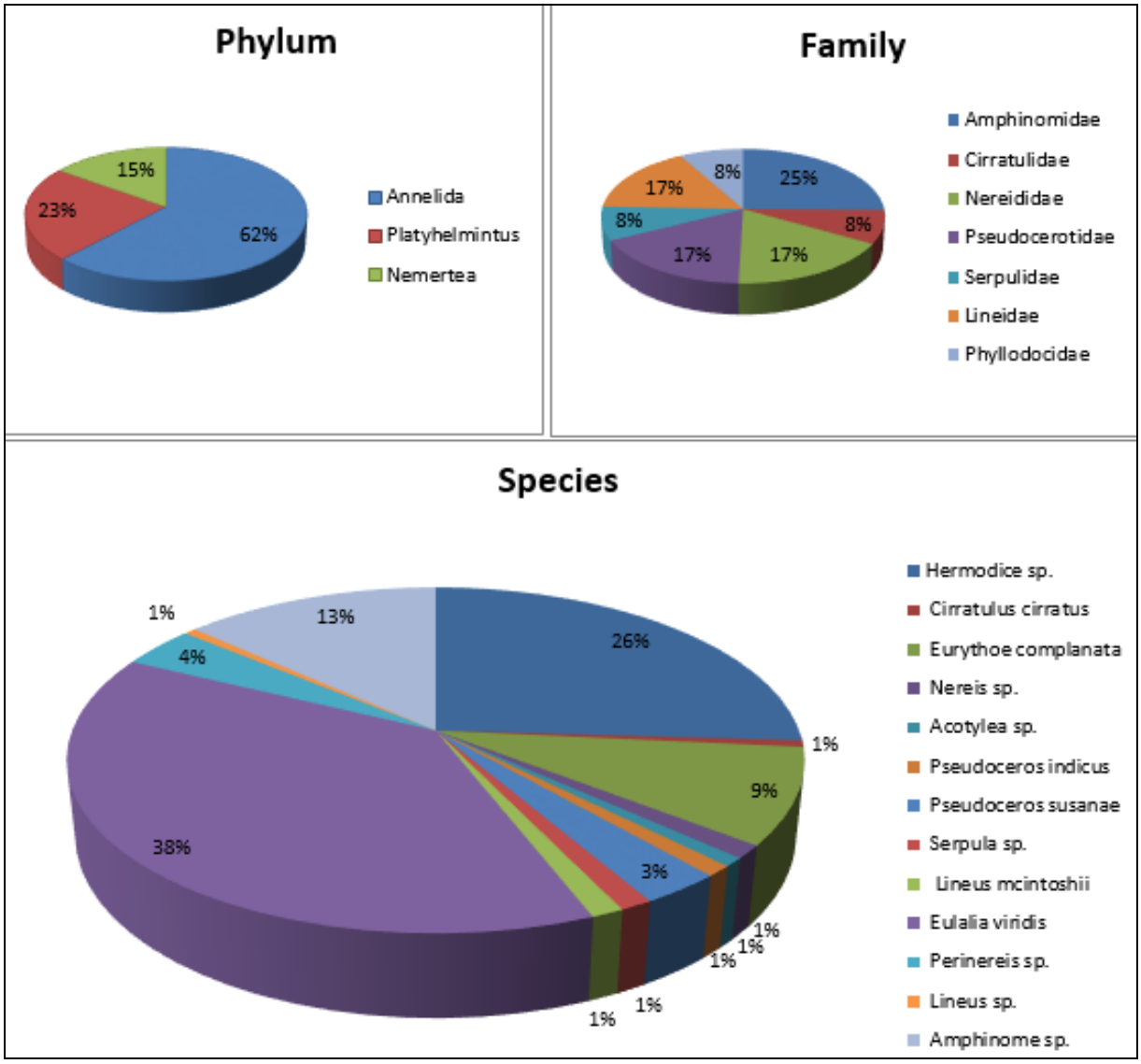


Chart 1: Frequency of Phylum, Family and species of all sites.

Phylum annelida is found in 62%, platyhelminthes 23% and Nemertea 15%. Family *Amphinomidae* is found 25% then *Nereididae, Pseudocerotidae, Lineidae* 17%, *Phyllodocidae, Serpulidae, Cirratulidae* 8%. And species *Eulalia viridis (Linnaeus,1767)* found is 38% then *Hermodice sp.* 26%, *Amphinome sp.*13%, *Eurythoe complanata (Pallas,1766)* 9%, *Perinereis sp. (Kinberg, 1865)*,4%, *Pseudoceros susanae* (*Newman & Anderson,1997)* [23, 24] 3%,*Lineus mcintoshii (Langerhans,1880),Cirratulus cirratus(O.F Muller,1776), Serpula sp., Pseudoceros indicus(Newman & Schupp,2002), Nereis sp., Lineus sp., Acotylea sp.*1%.

Table 2: Total Range of Water quality parameters

Sr. No.	Parameters	Total Range
1.	Air Temperature (°C)	18.1 - 33.2
2.	Water Temperature (°C)	22.8 - 31.1
3.	PH	8.1 - 8.3
4.	TDS (PPT)	32 - 34.4
5.	Turbidity (NTU)	16 - 19
6.	Salinity (‰)	21.3 - 23.4

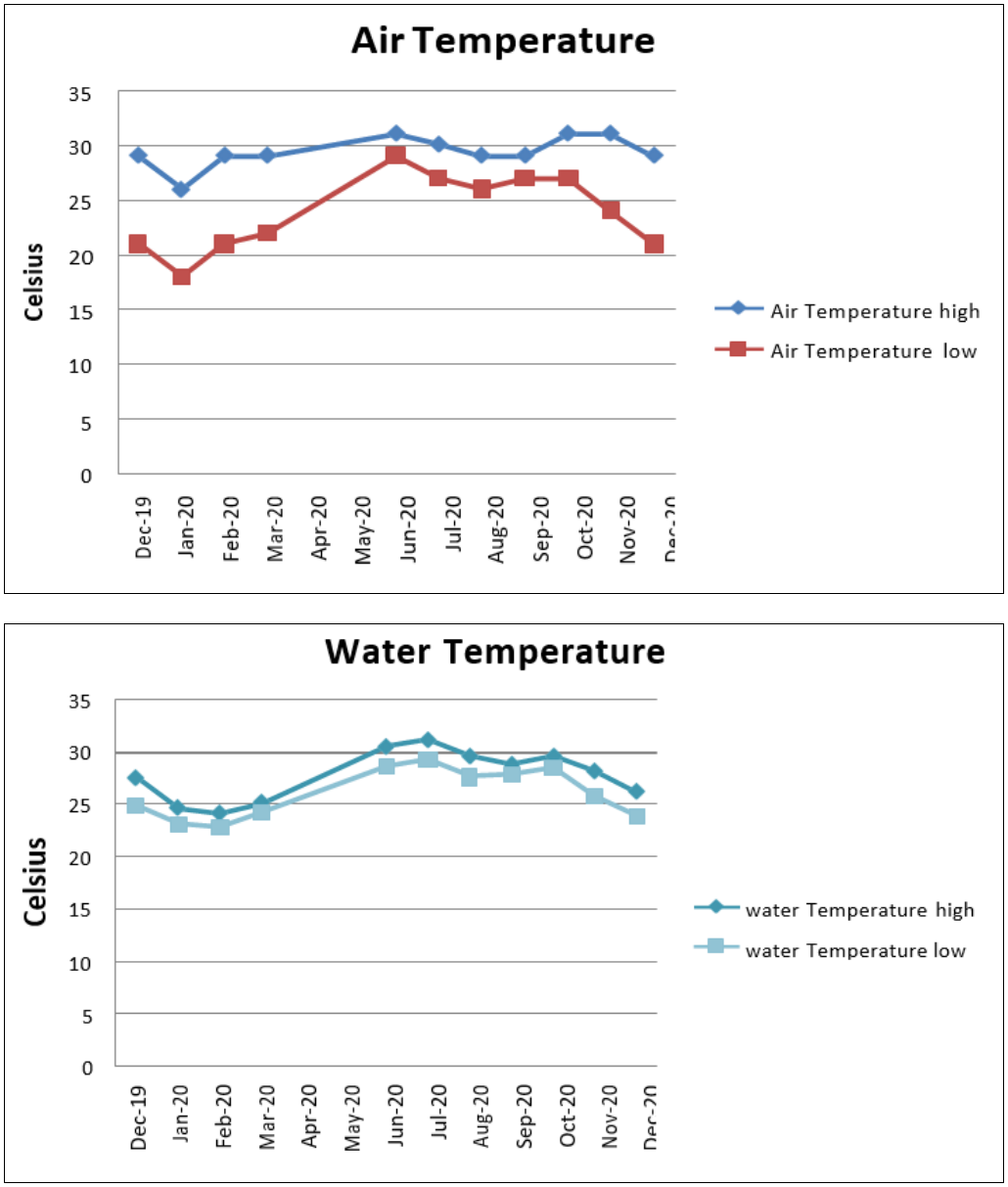
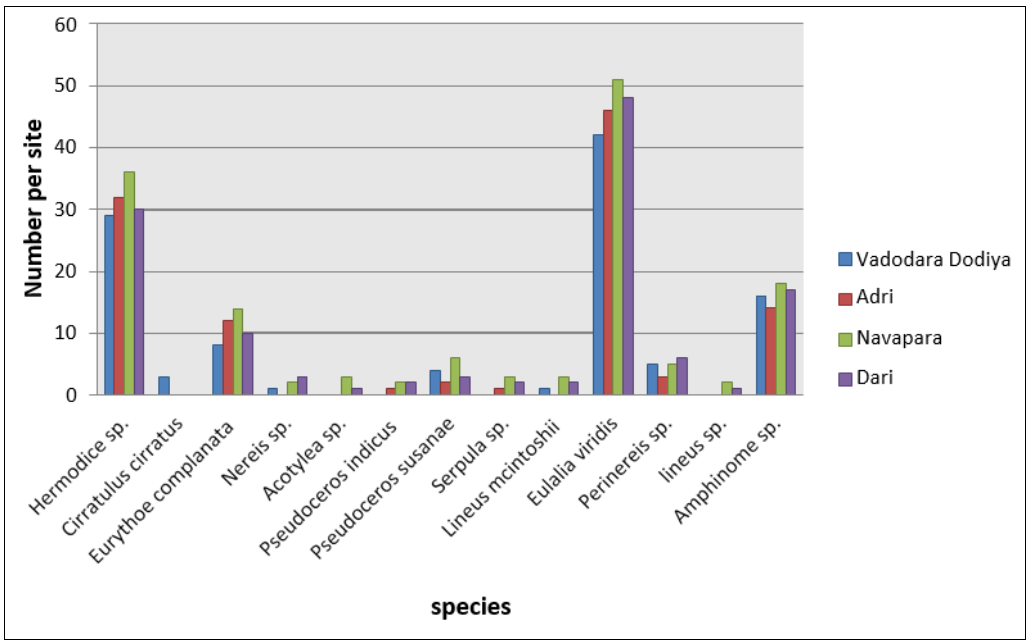


Chart 2: Yearly Fluctuations of Air Temperature and Water Temperature



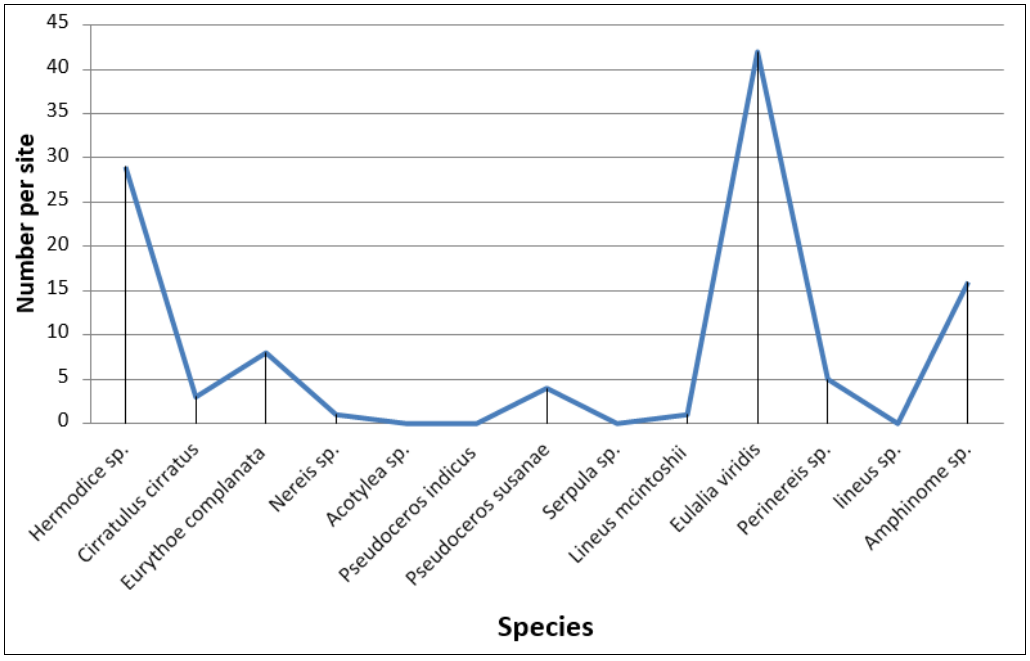


Chart 3: Diversity of Marine Worms Different Study Sites

Navapara site had highest species Diversity in comparison to other sites and ***Eulalia viridis*** was found to be highly abundant.

Table 3: Diversity indices of study sites

	Study sites			
Diversity indices	**Vadodara Dodiya**	**Adri**	**Navapara**	**Dari**
Taxa_S	9	8	12	12
Individuals	109	111	145	125
Dominance_D	0.2506	0.2837	0.2148	0.2343
Simpson_1-D	0.7494	0.7163	0.7852	0.7657
Shannon_H	1.641	1.48	1.864	1.784
Evenness_e^H/S	0.5732	0.5492	0.5375	0.4961
Brillouin	1.519	1.377	1.734	1.646
Menhinick	0.862	0.7593	0.9965	1.073
Margalef	1.705	1.486	2.21	2.278
Equitability_J	0.7467	0.7118	0.7501	0.7179
Fisher_alpha	2.327	1.978	3.105	3.27
Berger-Parker	0.3853	0.4144	0.3517	0.384
Chao-1	10	8.5	12	12.25

All the study areas are essentially similar in terms of the diversity of marine worms. This could due to the selection of study sites are present in a stretch of 10kms in Gir somanath district. To assess the difference between the studies sites, specific diversity indices were used which are as follows:

Dominance-D: In Aadri (0.2837), the absence of 5 species shows the dominance of the other 8 species. Thereafter, the absence of 4 species in Vadodara dodiya (0.2506) shows the dominance of the other nine species. In Dari (0.2343) and Navapara (0.2148) sites, absence of one species shows dominance of other 12 species.

Simpsons-1-D: Dominance index shows the inequality between the species present.Whereas, Simpson index represents the evenness within the species community. Based on that, we can rank the sites based on receding evenness *viz*., Navapara (0.7852), Dari (0.7657), Vadodara dodiya (0.7494), and Adri (0.7163).

Shannon-H Index: According to Shannon index Navapara (1.864), Dari (1.784), Vadodara dodiya (1.641) and Adri (1.48) shows the species diversity in descending order.

Evenness index: This index can be calculated by dividing the shannon index by the taxaS. Therefore the sites can be ranked as Vadodara dodiya (0.5732), Adri (0.5492), Navapara (0.5375) and Dari (0.4961) as this shows the relation between taxa and number of individuals.

Brillouin Index: This index is directly influenced by the Abundance hence the sites in descending order are as follows Navapara (1.734), Dari (1.646), Vadodara dodiya (1.519) and Adri (1.377)

Menhinick & Margalef Index: These indices show species richness therefore in terms of algae and organism the most fertile site is Dari (1.073, 2.278), Navapara (0.9965, 2.21), Vadodara dodiya (0.862, 1.705) and Adri (0.7593, 1.486).

Equitability: (also known as Pielou's evenness). Shannon diversity divided by the logarithm of number of taxa. This measures the evenness with which individuals are divided among the taxa present. Therefore the sites can be ranked as Navapara (0.7501) Vadodara dodiya (0.7467), Dari (0.7179), Adri (0.7118).

Fisher-alpha index: This index shows the mathematical relation between species richness and number of individuals therefore Dari (3.27), Navapara (3.105), Vadodara dodiya (2.327) and Adri (1.978).

Berger-parker Index: This index can be derived by a simple mathematical calculation and shows relation between abundance and species richness. Therefore the sites are ranked as follows Adri (0.4144), Vadodara dodiya (0.3853), Dari (0.384) and Navapara (0.3517).

Chao-1 Index: chao-1 is a nonparametric method for estimating the number of species in a community. This index is useful for species with low abundance. Therefore the sites are ranked as Dari (12.25), Navapara (12), Vadodara dodiya (10) and Adri (8.5).

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