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EFFECTS OF ORGANIC AND INORGANIC POLLUTION ON MACROBENTHIC COMMUNITIES ALONG THE COAST OF KERALA, SOUTH WEST COAST OF INDIA

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ABSTRACT

The present paper explores the effects of environmental variables on macrobenthic community along the coast of Kerala. The sites selected for study were Varkala (8º 43' NL & 76 º 43' EL-Site I) which is prone to tourist influx, being a religious pilgrimage center and Chavara (9º 07' NL & 76 º 31' 55 EL-Site II) which is a main source of inorganic pollution(trace metals and PAHs)from Kerala Minerals & Metals Ltd, Titanium dioxide factory effluent. Seasonal sampling (pre- monsoon, monsoon & post-monsoon) was carried out from February 2015 to January 2016. Sedimentological parameters such as temperature, heavy metals (Pb, Cd, Cr and Zn), PAHs, texture and organic carbon were analyzed. The investigation revealed 24 taxa belonging to 634 individuals exhibiting variations between seasons and sites. At site 1, both Terebra sp (predator sea snails) and Bullia sp were found during post-monsoon. The IUCN red listed major threatened species, Telescopium telescopium found only during monsoon, is likely impacted locally by loss of habitat. Both Natica vittellus (moon snails), Bursa sp (frog shells) were found only at site2 during pre-monsoon. The presence of Perna viridis at site 2 indicates pollution caused by heavy metals and organochlorides. The study reveals the deleterious and toxic nature of heavy metals found at site 2 which pose serious threat to human health, living organisms and natural ecosystems. The study also provides an insight into impact of several anthropogenic stressors on the macrobenthic faunal distribution along the coast of Kerala.

Key-word : Macrobenthos, Biomonitor, Inorganic pollution, PAHs, Heavy metals.

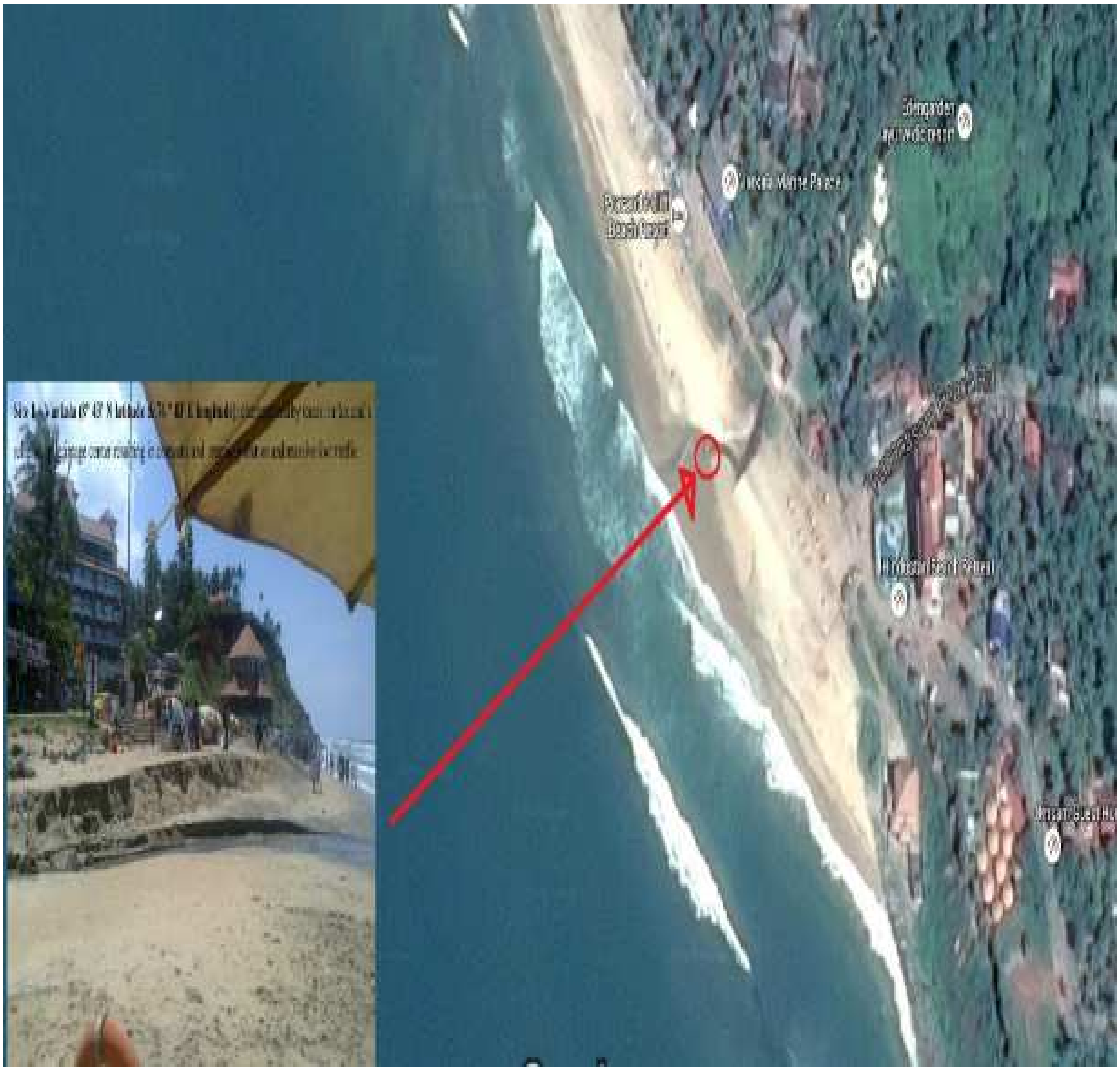
INTRODUCTION

Marine ecosystems provide a wide range of essential benefits to the society, which include food and other products, waste assimilation, coastal protection, climate regulations and important cultural and aesthetic benefits. These benefits to a considerable degree are underpinned by ecosystem services dependent on efficient functioning of the ecosystems in turn, linked to number and identity of the species present, as well as their prevailing environmental conditions (Tasman *et al*, 2015).

The study of macrobenthos has received considerable attention due to their significance as biological indicators of environmental change in aquatic ecosystems and also as sources of fish food for organisms. When the water bodies are subjected to sewage and industrial pollution, a considerable stress result on their faunal communities. The abundance of benthic animals in any area has close relationship with its environment and is regarded as an indicator organism, denoting nature of the particular ecological niche. Structural change in marine benthic communities caused by different disturbances seem to be rather predictable and may be used to assess the overall health of oceans and estuaries (Frouin, 2000). Hence, any changes in the benthic community structures are widely used in pollution assessment studies (Warwick and Clarke, 2009).In the present study, an effort has been made to assess the macrobenthic community in relation to environmental stressors along the coast of Kerala, south west coast of India.

MATERIALS AND METHODS

Study Area: The sites selected for the study were Varkala (***8º 43' N latitude & 76 º 43' E longitude - Site* I**) which is prone to tourist influx, being a religious pilgrimage center and Chavara (***9º 07' N latitude & 76 º 31' 55 E longitude -Site II***) which is a main source 3 of inorganic pollution (trace metals and PAHs) from Kerala Minerals & Metals Ltd, Titanium dioxide factory effluent *(Fig i).*



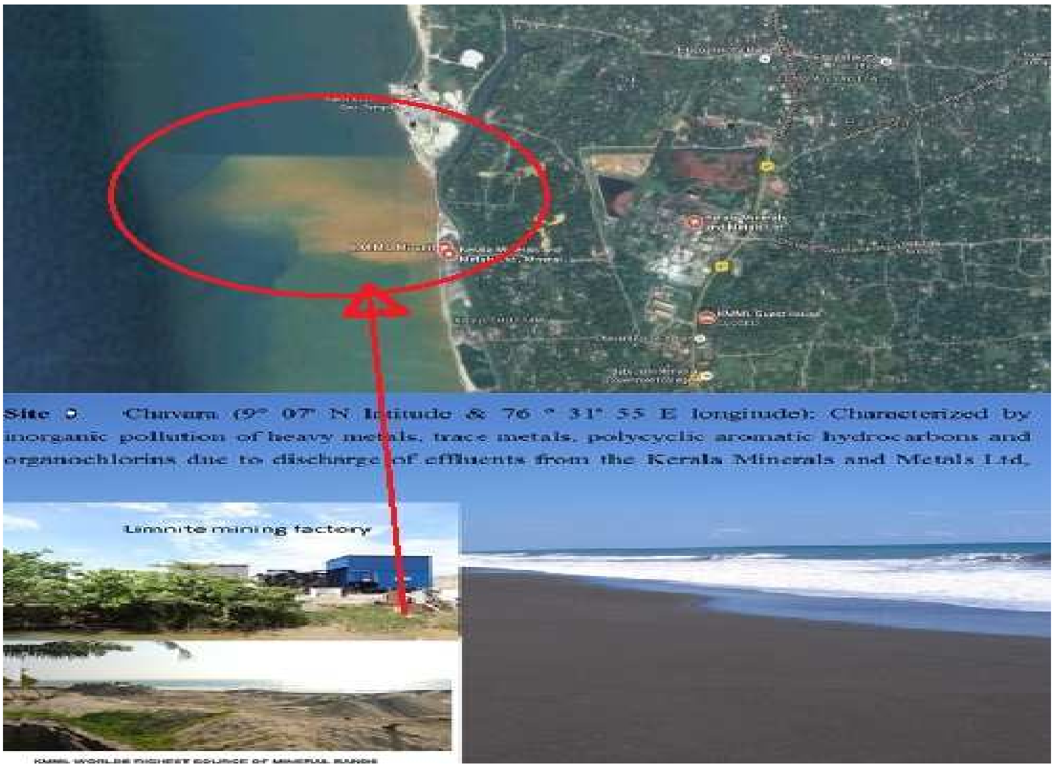


Fig 1& 2: Google earth map of Kerala showing the study sites

Sampling protocol: Seasonal sampling *(pre- monsoon, monsoon & post-monsoon)* was carried out from February 2015 to January 2016. Samples were collected using a Van Veen grab having a mouth area of 0.1 m2 along 5 transects off Varkala and Chavara along the near shore region (1 km from shoreline). Triplicate samples were taken and passed through a 0.5 mm mesh sieve and the benthic fauna retained on the sieve were fixed in neutral formalin-Rose-Bengal mixture and stored in 70% ethanol for further laboratory analysis and identification. Sediment samples were collected for analysis using Grab (Tagliapietra and Sigovini, 2010).

Laboratory Analysis: Sedimentological parameters such as **Sediment temperature** was recorded with a thermometer, **Texture** was determined by Pipette Analysis *(Krumbein and John, 1938)*, **Organic carbon** by wet organic carbon method *(Wakeel and Riley, 1957),* **heavy metals (Pb, Cd, Cr and Zn)** using ICP-AES and **Polycyclic Aromatic Hydrocarbons (PAHs)** using GC-FID. **Analysis of Fauna:** The preserved fauna were identified to major taxonomic groups using appropriate keys (Pennak, 1978 and Olomukoro, 1996).The sedimentological data were expressed as mean and standard deviation. Correlation between benthos and sedimentological parameters were calculated using Pearson correlation coefficient using SPSS (Ver.20) ecological software.

RESULT AND DISCUSSION

The benthic macrofauna found at the study sites were sorted and identified up to the lowest possible level (Table i). The present investigation revealed 24 taxa belonging to 634 individuals exhibiting variations between seasons and sites. The fauna is mainly composed of Bivalves (317 No/m2), Gastropods (290 No/m2) and Scaphopods (27 No/m2). During the monsoon season, the gastropods represented the dominant group at both the study sites and the second largest group was bivalves during the post monsoonseason at site 1 and the least dominant group where the scaphopods during pre and post monsoon. Based on analysis, the seasonal average of each species also exhibited variations in their abundance.

Table 1: List of macrobenthic assemblages at the study sites

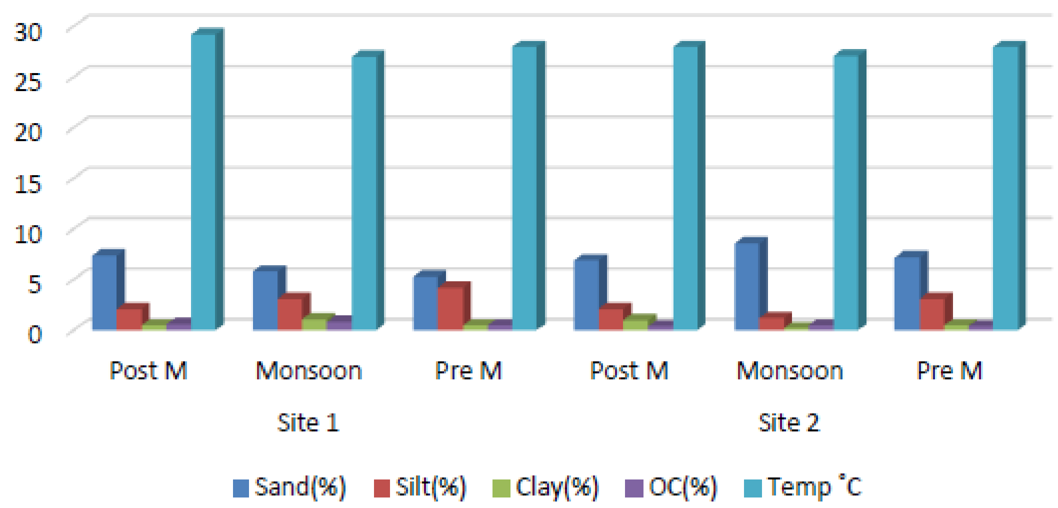
Taxa	SITE 1			SITE 2		
	Mon	**Post-mon**	**Pre-mon**	**Mon**	**Post-mon**	**Pre-mon**
						GASTROPODS
Architechtonica sp	-	-	*	-	***	**
Bullia melenoides	-	**	-	-	-	-
Bullia sp	**	***	-	-	-	-
Bursa elegans Sowerby	*	-	-	-	-	*
Bursa tuberculate	-	*	-	-	-	*
Nassarius olivacea	-	-	-	*	-	-
Natica sp	-	-	*		-	-
Natica vitellus Linne	-	-	-	-	-	*
Oliva reticulata	**	-	-	-	-	-
Oliva sp	-	-	-	-	-	-
Telescopium telescopium	*	-	-	-	-	-
Terebra dimidiata Linne	-	***	-	-	-	-
Terebra palustris	-	***	-	-	-	-
Trochus stellatus	-	-	*	-	-	-
Trochus tentorium	-	-	*	-	-	-
Tueitella terebra Linne	-	-		-	-	*
Turitella javanica	-	-		*	-	-
Umbonium sp	***	-	*		-	-
BIVALVES						
Anodontia edenticula	-	-	-	*	-	-
Arca decussata(Linn)	-	-	-	*	-	-
Perna viridis	-	-	-	*	*	-
Siliqua radiata	-	-	-	-	***	-
Vepricardium coronatum	-	-	-	-	**	-
Anadara granosa	*	-	*	*	-	-
Anodontia edenticula	-	-	-	*	-	-
Mactra luzonica Reeve	-	-	-	-	*	*
Mactra sp	-	-	-	-	**	**
SCAPHOPODS						
Dentalium sp	-	***	*	-	-	-

* *Presence,* - *Absence, **Common,*** Abundant*

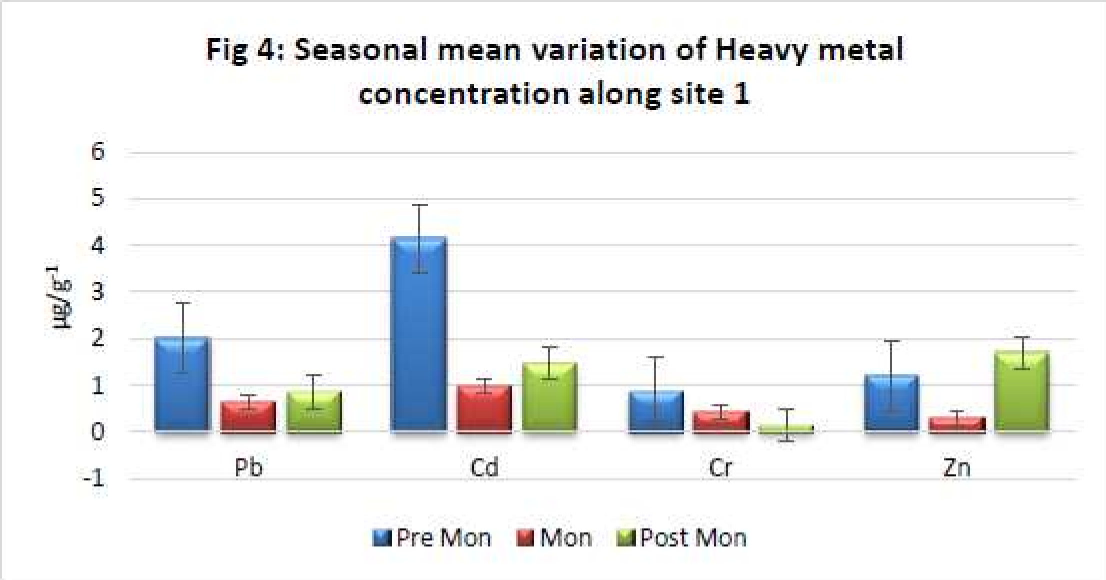
Sediments are considered as important indicators of environmental pollution; they act as permanent or temporary traps for materials spread into the environment (DeGregori *et.al,* 1996). Based on seasonal analysis of the sediment, temperature is considered as an important ecological factor, which influences distribution of the benthic organisms which in turn regulates various abiotic and biotic activities of an ecosystem. Sediment temperature was maximum (29.20 C ± 1.1) during pre-monsoon and minimum (270 C ± 0.5) during monsoon at site 1, which can be attributed to human activities along the coastal zone resulting in direct or indirect nutrient inputs (Howarth *et.al,* 2000).

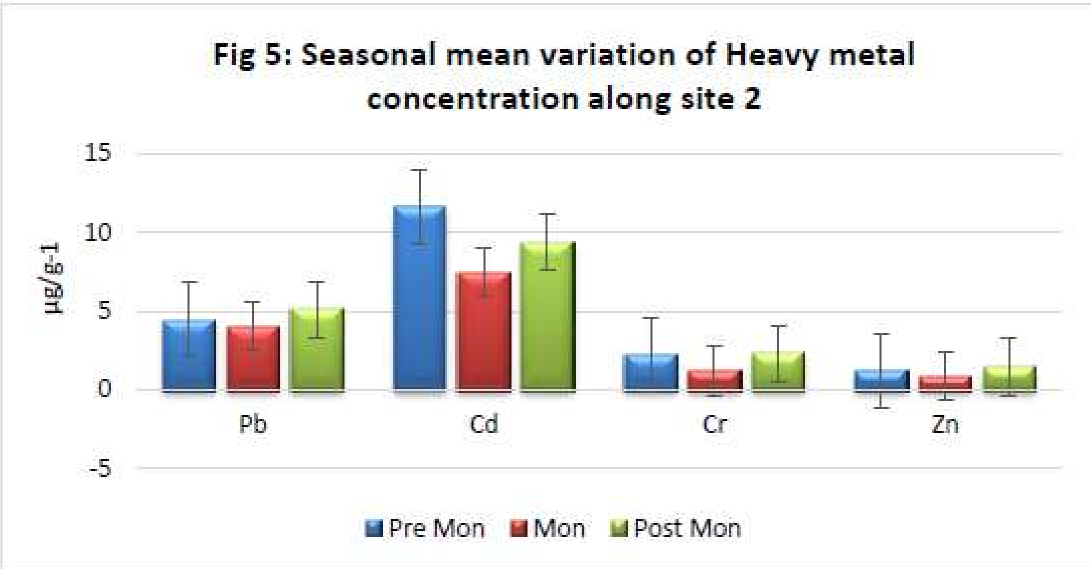
The percentage of organic carbon in sediment, influences the occurrence and distribution of benthic organisms (Ansari *et al.*, 1986). Organic carbon showed its highest value (0.84 ± 0.17) during monsoon at site 1 and minimum (0.4 ± 0.05) during pre and post- monsoon at site 2. The textural characteristics of sediment play a crucial role in the distribution and concentration of carbon, nitrogen, phosphorus and bio-organisms (Gray, 1974). Sediment texture showed maximum percentage of sand (8.6 % ± 0.9) during monsoon at site 2 whereas during pre-monsoon, silt is maximum (4.2 % ± 1.1) at site 1. Clay is found at its maximum (0.5 % ± 0.2) during pre-monsoon at site 2. The high amount of clay reflects an increase in fine particles and such fine particles compounded with organic constituents elevated the benthic metabolism (Meksumpun, 1999). This leads to a marked decline in sediment O2 content (Pearson, 1980) leading to anoxic conditions which may be due to the decrease in species abundance and diversity (Fig 3).

Fig 3: Seasonal variation of Sedimentological parametrs along the study sites



In the present study, heavy metal concentration levels vary due to source contributions. Temporal and spatial distribution of average metal concentration at the two sites were in the order S1 :(Cd> Pb > Zn>Cr), S2 :(Cd>Pb>Cr >Zn). During pre-monsoon, site 2 showed maximum concentration of metals compared to site 1 (Fig 4 & 5). This is due to the KMML effluents discharged into the marine environment at this region, without proper detoxification. Similar observations were also made by D'Cruz and Miranda 2005.





PAHs are well known environmental pollutants and they are also included in the priority pollutant list of European Union and US Environmental Protection Agency (EPA), due to their mutagenic and carcinogenic properties (Chimezie A. et al, 2005; Zhang Z. et al. 2004). Of the total PAHs (Σ16) listed (Table 2), twelve (Naphthalene, Anthracene, Benzo[a]anthracene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[a]pyrene, Benzo [ghi] perylene and Indeno [1, 2, 3-cd] pyrene) were detected at varying concentrations during pre and post-monsoon at site 2 (Table 3) and the presence of seven in the marine environment has been shown to be carcinogenic to experimental animals (Rubailo et al., 2008).Seasonal variation of total PAHs at the study sites are shown in figure 6.

Table 2. USA EPA priority list of PAH

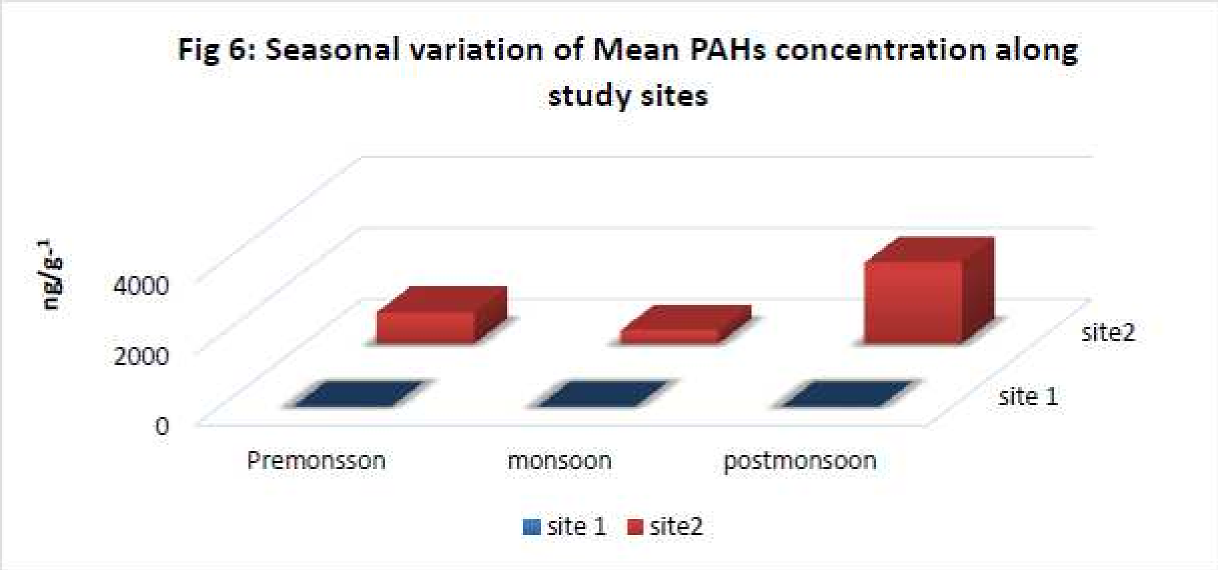
Compound	Total molecular formula	Molecular weight	Carcinogenic activity
Naphthalene	*C10H 8*	*128*	+
Phenanthrene	*C14H10*	*178*	-
Anthracene	*C14H10*	*178*	±
Fluoranthene	*C16H10*	*202*	-
Pyrene	*C16H10*	*202*	-
Chrysene	*C18H12*	*228*	±
Benzo(a)anthracene	*C18H12*	*228*	+
Benzo(b)fluoranthene	*C20H12*	*252*	++
Benzo(k)fluoranthene	*C20H12*	*252*	+
Benzo(e)pyrene	*C20H12*	*252*	±
Benzo(a)pyrene	*C20H12*	*252*	+++
Perylene	*C20H12*	*252*	±
Benzo(ghi)perylene	*C22H12*	*276*	±
Dibenzo(ah)anthracenes	*C22H14*	*278*	+++
Indeno(cd)pyrene	*C22H12*	*276*	+
Coronene	*C24H12*	*300*	±

+ (++): there is sufficient evidence that substance is carcinogenic to experimental animals; ±: the available data are inadequate to permit an evaluation of the carcinogenicity of substance to experimental animals, - : The available data provide no evidence that substance is carcinogenic to experimental animals.

Table 3: Seasonal Occurrence of Sediment PAHs along the study sites

Components(ng/g-1)	Station 1			Station 2		
	PREM	MN	PSTM	PREM	MN	PSTM
Naphthalene	+	+	+	++++	++	++++
Acenaphthylene	0	0	0	BDL	BDL	BDL
Acenaphthene	0	0	0	BDL	BDL	BDL
Fluorene	0	0	0	+	+	+
Phenanthrene	+	+	0	+	BDL	BDL
Anthracene	+	+	0	+	++	++
Fluoranthene	+	+	+	+	+	+
Pyrene	+	+	0	+	+	+
Chrysene	0	0	0	BDL	BDL	BDL
Benzo[a]anthracene	0	0	0	BDL	BDL	BDL
Benzo[b]fluoranthene	+	+	0	+	++	+
Benzo[k]fluoranthene	0	0	0	BDL	BDL	BDL
Benzo[a]pyrene	+	0	0	+	+++	++
Dibenzo[a,h]anthracene	0	0	0	+++	BDL	BDL
Benzo[ghi]perylene	0	0	0	BDL	++	BDL
Indeno[1,2,3-cd]pyrene	0	0	0	+	+	+

++++ Abundant, ++ less abundant, + Presence, BDL-Below Detection Limit



The correlation matrix between sedimentological parameters and benthic fauna at the study sites are shown in Tables 4 & 5.At site 1, Gastropods shows a significant positive correlation with silt, clay and Zn; while temperature, organic carbon, sand, Pb, Cd, Cr, Zn and PAHs shows a negative correlation. Silt, Zn and PAHs shows a positive relation with bivalves and negative relation with temperature, sand, clay, Pb, Cd and Cr. Scaphopods showed strong positive relation with temperature, sand, Pb, Cd, Cr, Zn and PAHs; while organic carbon, silt and clay shows negative relations. At site 2, Gastropods and bivalves shows a significant positive correlation with temperature, silt, Pb, Cr, Zn and PAHs and sand, clay, organic carbon and Cd shows negative correlation.

Table 4: Correlation matrix between sedimentological parametrs and benthic fauna at site 1

	TMP	OC	Sand	Silt	Clay	Pb	Cd	Cr	Zn	PAHs	Gastropods	Bivalves	Scaphop
TMP	1												
OC	-0.6477	1											
Sand	0.764144	-0.00348	1										
Silt	-0.52145	-0.31237	-0.94887	1									
Clay	-0.83863	0.958187	-0.28947	-0.02748	1								
Pb	0.948893	-0.37414	0.928666	-0.7641	-0.62386	1							
Cd	0.945254	-0.36361	0.932812	-0.77136	-0.61496	0.999936	1						
Cr	0.609994	0.208638	0.977261	-0.99423	-0.07993	0.828901	0.83519	1					
Zn	0.590563	-0.99735	-0.06927	0.380641	-0.93483	0.305696	0.294882	-0.27923	1				
PAHs	0.874059	-0.93627	0.354531	-0.04124	-0.99764	0.676064	0.667667	0.148204	0.90824	1			
Gatropods	-0.64582	-0.1634	-0.98599	0.988234	0.12573	-0.85377	-0.85962	-0.99894	0.23473	-0.19357	1		
Bivalves	-0.40628	-0.43304	-0.89986	0.991539	-0.15701	-0.67389	-0.68222	-0.97189	0.49746	0.088808	0.9600195	1	
Scaphop	0.998625	-0.68674	0.729285	-0.47601	-0.86603	0.931047	0.92685	0.567622	0.63205	0.898321	-0.6049174	-0.35783	1
	* P < 0.05; ** P < 0.01												

Table 5 : Correlation matrix between sedimentological parameters and benthic fauna at site 2

	TMP	*OC*	*Sand*	*Silt*	*Clay*	*Pb*	*Cd*	*Cr*	*Zn*	*PAHs*	*Gastropods*	*Bivalves*
TMP	1											
OC	-1	1										
Sand	-0.98624	0.986241	1									
Silt	0.850439	-0.85044	-0.75177	1								
Clay	0.785714	-0.78571	-0.87716	0.342779	1							
Pb	0.790467	-0.79047	-0.67834	0.994466	0.242192	1						
Cd	0.84415	-0.84415	-0.92116	0.435867	0.994891	0.338904	1					
Cr	0.991405	-0.9914	-0.95614	0.911956	0.69803	0.863807	0.766754	1				
Zn	0.933889	-0.93389	-0.86193	0.98232	0.512586	0.957217	0.596651	0.972643	1			
PAHs	0.703536	-0.70354	-0.57638	0.972173	0.113171	0.991404	0.212899	0.790465	0.91113	1		
Gatropods	0.281539	-0.28154	-0.11904	0.744225	-0.37236	0.810276	-0.27676	0.404658	0.60603	0.879986	1	
Bivalves	0.157287	-0.15729	0.008131	0.653288	-0.48731	0.729211	-0.39666	0.285138	0.5	0.812471	0.9918886	1

* P < 0.05; ** P < 0.01

At site 1, both Terebra sp (predatory sea snails) and Bullia sp (mud snails) were found during post-monsoon. The IUCN red listed major threatened species, Telescopium telescopium was found only during monsoon, which is less likely to be impacted locally by loss of habitat. Dentalium sp (Tusk shells) are present at site 1 both during pre and post monsoon, which are possible indicators of early social stratification. Both Natica vittellus (moon snails) and Bursa sp (frog shells) were found only at site 2 during pre-monsoon. Perna viridis are excellent bio-indicators in areas of disturbances, and their presence at site 2 indicates concentration of heavy metals and organochlorides in that area.

CONCLUSION

The present study reveals that all contaminants found at the study sites are associated with reduced ecological imbalance in the ecosystem along the coast of Kerala. This realm is becoming more and more polluted and the pollution-sensitive species are being eliminated (e.g. *P. viridis*). The effects of pollution and degradation of a habitat can cause a decrease in the number of species and bring about a drastic change in the number of individuals of the macrofaunal assemblages. In this perspective, an improved information on the synchronicity of benthic changes in relation to ecosystem componentsand their response to human activities is required to understand variations in benthic structure which will have repercussions on the whole marine ecosystem, with consequences for ecosystem functioning and service, including climate control regulations.

RECOMMENDATIONS

Considerable effort is to be applied in the field of research and bio-monitoring of hazardous and potentially hazardous toxins in order to predict, control and minimize the negative effects of marine pollution. It is necessary to have precise information about their nature, sources and amount of emission to adopt stringent measures in order to delay their effect and prevent further growth of unwanted toxins from dissolving into the clear marine environment. Paying increased attention on minor disturbances in the marine environment can resolve problems to a certain extent.

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REFERENCES

[1] Anatoly I. Rubailo and Andrey V. Oberenko, Polycyclic Aromatic Hydrocarbons as Priority Pollutants, *Journal of Siberian Federal University. Chemistry,* **2008.** 344-354

[2] Ansari ZA Chatterji A and Parulekar AH, Effect of high organic enrichment on benthic polychaete population in an estuary. *Mar Poll Bull***. 1986**. 17, 361-365.

[3] Crabtree, Pam J.; Campana, Douglas V. (Eds.). Exploring Prehistory: How Archaeology Reveals Our Past *(2nd Ed.).* p. 233. ISBN 0-07-297814-7.Bu

[4] Davide Tagliapietra and Marco Sigovini, Benthic Fauna: Collection and identification of macrobenthic invertebrates, *Near Curriculum in Natural Environmental Science,, Terre et Environnement,* **2010***,* 88, 253-261, ISBN 2-940153-87-6.

[5] D'Cruz F G and Miranda MTP, Effect of the Titanium Dioxide industrial effluents on the plankton biomass of Vattakayal- an estuarine system in Kerala. *Uttar Pradesh J.Zool.* **2005**,25 (2):151-156.

[6] El-Wakeel S.K. and Riley, J.P. The determination of organic carbon in marine muds. *Journal du conseil permament Inti. Pourl. Exploration de mer*, **1956,** 22: 180-18Mar3.

[7] Frouin P. Effects of Anthropogenic disturbance of tropical soft bottom benthic communities *Marine Biology Progress Series.* **2000,**194: 39-53.

[8] Gray J S, Animal sediment relationships, *Oceanogr.Mar.Biol.Ann.Rev.* **1994**,223-261.

[9] Howarth. R, Anderson. D, Cloern. J, Elfrig.C, Hopkinson. C, Lapointe .B, Malone .T, Marcus .N, Mcglathery .K, Sharpley .A and Walker .D, Nutrient Pollution of coastal Rivers, Bays and Seas, *Issues in ecology,* **2000**,Number 7, fall**.**

[10] Krumbein, W.C. and Pettijohn, F.J. Manual of sedimentary petrography, Appleton -*Century Crafts, New York,* **1938,** 549*.*

[11] Mahmood Sinaei and Ali Mashinchian, Polycyclic aromatic hydrocarbons in the coastal sea water, the surface sediment and Mudskipper Boleophthalamus dussumeiri from coastal areas of the Persian Gulf; source investigation, composition pattern andspatial distribution, *Journal of Environmental Health Science and Engineering* **2014**,12;59.

[12] Meksumpun, C., & Meksumpun, S. Polycheate –Sediment relations in Rayong. Thailand. *Environ Poll*, **1999**,105, 447-456.

[13] Olomukoro, J.O. Macrobenthic fauna of Warri River in Delta State. Nigeria. Ph.D. thesis, *University of Benin, Nigeria,* **1996***.*

[14] Olomukoro, J.O. and Azubuike C.N. Heavy Metals and Macro invertebrate Communities in Bottom Sediment of Ekpan Creek, Warri, Nigeria. *Jordan Journal of Biological Sciences,* **2009***,* 2 (1): 1-8.

[15] Tasman P. Crowe Dave Raffaelli and Christopher L.J.Frid, Marine ecosystems –Human Impacts on Biodiversity, functioning and Services, *Cambridge University press,* June **2015.**

[16] Warwick R.M. and Clarke K.R. Changes in Community Structure of the soft bottom benthic macrofauna in relation to oil drilling activity at the Ekofisk platform *Journal of the Marine*

biological Society **2009.** 18: 86-91.

[17] Pearson T.H., Marine pollution effects of pulp and paper industry wastes. *Helgolander wiss.Meersunters,* **1980 ,**33:340-365.

[18] Pennak, R W. Freshwater Invertebrates of the United States. *Second edition. New York: John Wiley and Son,* **1978.**