Environmental analysis of sea sediments around ONGC installations of Mumbai high for monitoring of E&P impact on marine environment.

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Abstract : After discovery of Bombay High in 1974, ONGC has deployed several drilling rigs, process platforms and many unmanned platforms in Western offshore. As per requirements that the MoEF, Govt. of India has demanded, to fulfil the commitment of ONGC for protecting environment, IPSHEM, ONGC carries out regular monitoring of its oil fields and installations. In this aquatic environment, contamination and accumulation of pollutants in sediments will guide us better to assess the environmental stress around the focus area. Therefore, this paper focuses on analysis of hydrocarbon content, non-essential heavy metals like Lead, Chromium and Nickel along with biological study of bottom-dwelling living things i.e. macro benthos in the sea sediments near ONGC platforms and few other reference points of Mumbai High(BHR). Long term analysis for the years 1995 to 2012 has been also made for heavy metals and petroleum hydrocarbon to observe the trend of behavior of those environmental parameters. The trend behavior of PHC and benthic study of sea sediments reflects some minor influence of ONGC activities on marine environment.

Keywords: Marine Environment, aquatic ecosystem, ONGC, hydrocarbon contamination, heavy metals, benthic organisms.

I. INTRODUCTION

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The speedy population growth is accompanied with several human activities, notably the industrial unfair treatment of natural resources, additionally sewage and junk being tossed out to the sea lacking any treatment. They are frequently conveyed to the saltwater environment across rivers and perennial rivulet. Heavy metals exist at low levels of concentration in marine ecosystems where they apt to assemble in marine sediments to extend noxious levels and can keep hefty metals amid their coats and give a total chronology of the deposition mechanism. Even after deposition, detected metals may re-enter the water under certain environmental conditions. Hence, the sediments act as buffer capable of keeping the concentrations of metal in aqua and biota high above the background levels even after the input of the metal is stopped. Therefore, the scrutiny of levels of heavy metal in sediment specimens aids in the connotation of water standard (Heiny and Tate, 1997) [1]

Similarly hydrocarbon contamination into sediments brings un-favorable effects on benthic organisms. As benthic communities do a principal job in shifting substance from 1° (primary) manufacture by detrital pool to upper tropic levels, which includes commercially exploited fishes, the hydrocarbon pollution in sediment can affect the food web of aquatic organisms additionally it can affect even human being also. Moreover, in a benthic polluting environment, dominion of few opportunist species like Polychaeta will impact on the biodiversity of marine ecosystem.

Again, evaluation of the variations in marine ecosystem can be very well monitored by the help of benthic fauna because all pollutants ultimately will rest at seabed. Benthic organisms have crucial cast to play in transferring material from the lower 1° (primary level) via. detrital pools to higher tropic levels. Benthic organisms primarily are inactive and immobile in nature and cannot dodge any habitat perturbation, therefore are contemplated delicate indicator of changes in its environment due to anthropogenic or natural disturbances. ABC (Abundance Biomass Comparison) curves have conceptual background in classic theory of evolution of k-selection and r-selection. When left undisturbed, the k-selected species is supposed to dominate the community (late maturing, grows slowly, large in size), & the abundance curve lies below the biomass curve. With increase in disturbances, species which are slow-growing cannot survive, and the r-selected species dominate the system (opportunistic, grows fast, small in size), & the abundance curve comes above the biomass curve. (Warwick and Clarke, 1994) [2]

In view the above, regular monitoring of the concentration level of heavy metals, benthic fauna and hydrocarbon content in aquatic environment is very essential. In this paper, we are trying to analyse heavy metals and hydrocarbons present in sediments across the years 1995-2012 around the ONGC offshore installations. Attempts have been established to observe variation of results across the years i.e. from 1995-2012.Also with the help of Biomass and Abundance of benthic fauna, effort has been made to find out the overall environmental status of the investigation sector.

II. MATERIALS AND METHODS

2.1 Study Area

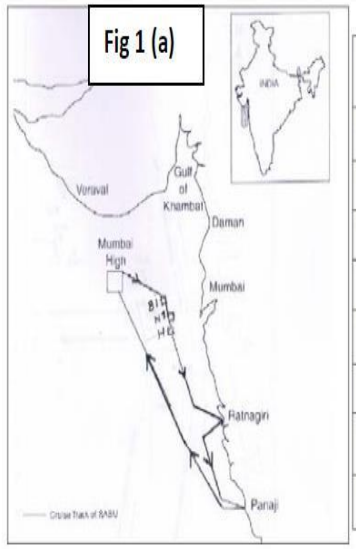
This study area has covered oil and gas fields of ONGC in the Western continental shelf are shown in Fig. 1(a).

2.2 Field Sampling

Based on Paris Commission Guidelines (1987) [3] and keeping in view the pipeline network in the vicinity of the platforms in addition to sea state and maneuverability of the vessel around the installations, samples are collected at stations scattered in circles of 250m, 500m, 1000m and 2000m surrounding each installation. Reference samples were collected beyond 6 kms from the installations as shown in Fig. 1(b).

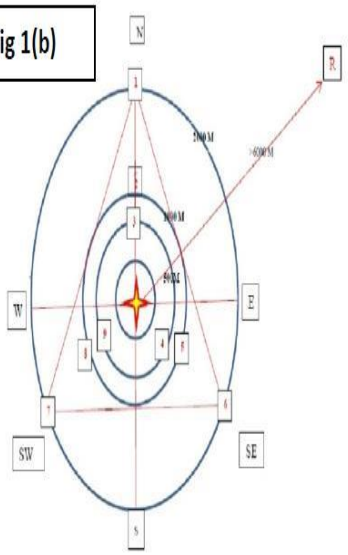
A Van Veen grab of 25 cms x 30 cms dimension and approximately 1.5 kg capacity having a penetration depth of 10 cm was used for collection of sediments. This medium version of the grab was used to prevent likely damage to pipelines etc. in case of any accidental strike on flow lines. Sea bottom dwelling organisms or benthos are also collected in the same way.

Fig 1 (a)



Platform	Depth (m)
N-1	56
B-1	51
H	53
S	70
B-2	78
I	75
N-2	73
N-3	65

Fig 1(b)



2.3 Laboratory Analysis

Sediment samples collected around installations from different stations are taken for further digestion. After making it dry, the samples are digested with hydrofluoric acid followed by per chloric acid, nitric acid and hydrochloric acid to get a clear liquid. Inductively Coupled Plasma-Optical Emission Spectrophotometer was used to measure the concentration of heavy metals from this clear liquid sample. For PHC in sediment, the sediments collected from each station were digested with per chloric acid and PHC is being measured using Fluorescence spectrophotometer. All the macrofaunal samples were processed on board after 48 hrs of collection using 500 micron stainless steel mesh screen in filtered seawater and material retained on sieve mesh were fixed in 5% formalin Rose Bengal. Within the laboratory, all the fauna was stored, identified up to the lower possible level under the Microscope. Biomass (wet weight) was measured by blotting the sample on a blotting paper and weight was taken by direct weighing on balance. The biomass was calculated in g/m^2.

2.4 Data Analysis

- Heavy Metals

Results of above mentioned analysis revealed concentrations of metals like Nickel, Chromium, Lead and Barium. Considering data around entire study area, year wise concentration of each metal has been tabulated i.e. from 1995 to 2012 and accordingly plotted in scattered diagram of Microsoft Excel-2010 as shown in Fig 2 (a), 2(b), 2(c) and 2 (d). Later on one trend line has been drawn for each metal to observe the change of behavior.

- Petroleum Hydrocarbon

From 1995 to 2012, year wise concentration of PHC has been tabulated considering the data around the whole study area and accordingly plotted in Scatter Diagram of Microsoft Excell-2010 as shown in Fig.3. After that, one trend line has been drawn over the graph to see the overall variation within the time period.

discount rate leads to decrease the cash flow's present value (Jecheche, 2010). The purchasing power of money decreased due to inflation, and due to which the investors demand high rate of return, and the prices decreased with increase in required rate of return (Iqbal et al, 2010).

- Abundance-Biomass Comparison Curve

Abundance i.e. mean density of different macro benthic species around each station of an installation are counted as numbers/ meter. The area between the two curves shows the difference between them and is known as W-statistic. Although, ABC curves of each installation are constructed separately but in this paper ABC curve of entire Mumbai High area has been constructed in a single curve. ^{2} and the total biomass of different stations are measured as gm/m^2 as listed tables. Now, the tables of abundance and biomass of different stations of a particular installation are incorporated in the software (primer V6). After running the software as "cumulative dominance curve" one ABC curve is formed where in y- axis we will get "cumulative dominance %" and in x-axis "species rank" will appear.

III. Results and Discussions

3.1. Heavy Metals

- Nickel

Concentration of Nickel found higher during 2010 and overall trend of variation during the time period 1995 to 2012 observed almost constant line as shown in Fig. 2(a).

- Chromium

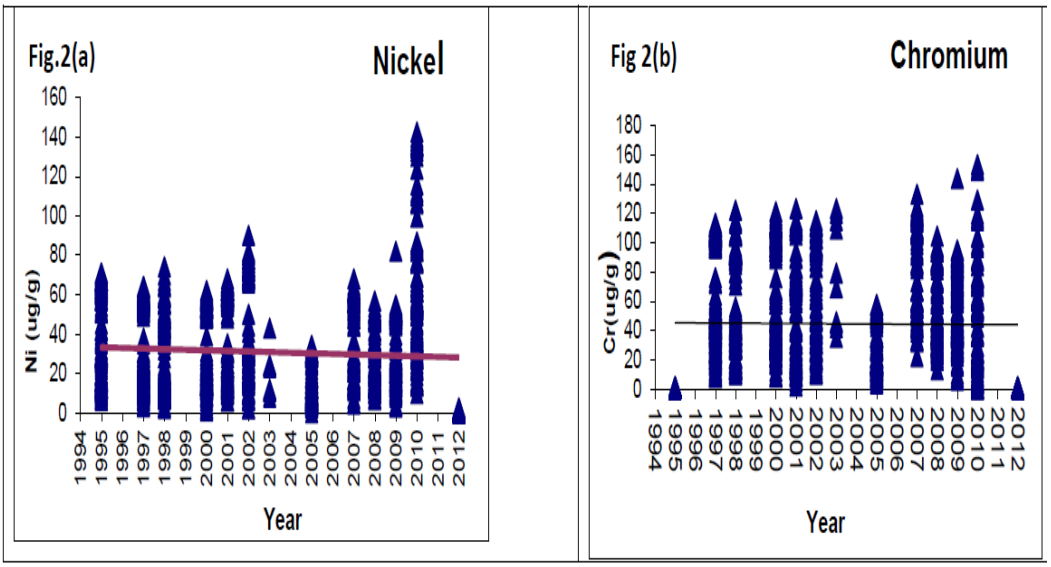
Contamination of Chromium observed minimum during 2005 and found maximum during 2010. Overall trend of variation of Cr during 1995 to 2012 found almost line. Fig. 2(b).

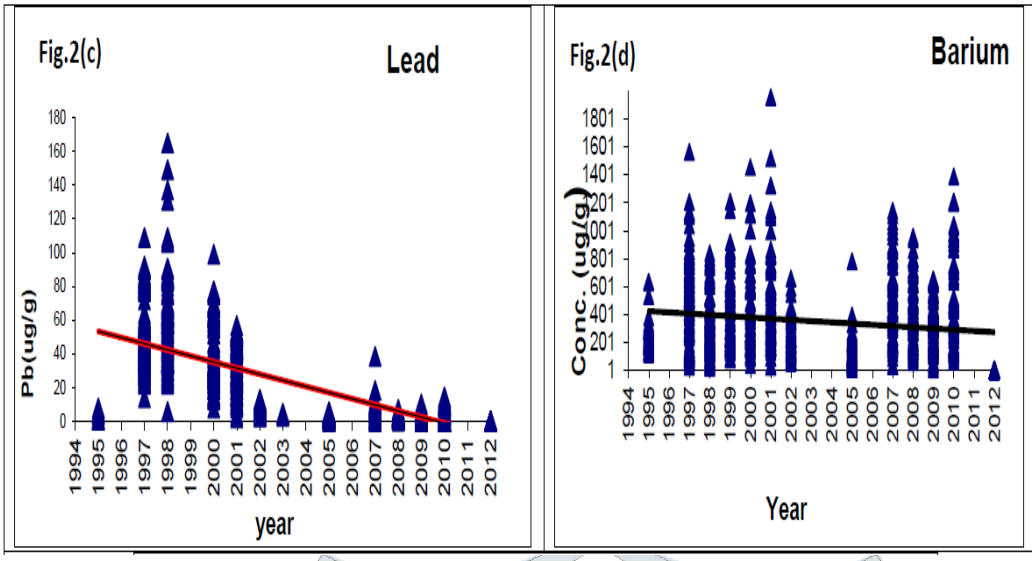
- Lead

Considering concentration of Lead from all the stations around the overall study areas, it has been observed that during the year 1998, sediments of the study areas were more contaminated with lead and after 2008, it starts decreasing during subsequent years. The overall trend of Pb is decreasing as shown in Fig. 2(c).

- Barium

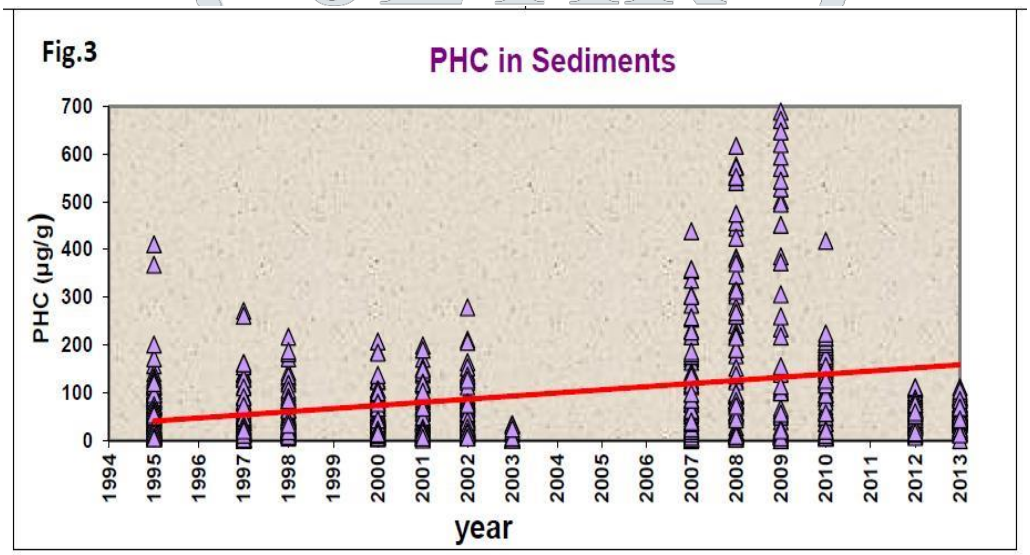
Considering the study area as entire western offshore area, sediments were more contaminated with Barium during the year 2001 and concentration was minimum during 1995. The overall trend of behavior from 1995 to 2012 is almost parallel as shown in Fig. 2(d).





3.2. Petroleum Hydrocarbon

Petroleum Hydrocarbon in sea sediments around Western Offshore area found increasing from 2007 to 2009 and decreases from 2010 onwards. During the period of 2007 to 2009, sea sediments around the study area were contaminated severely and overall trend of variation found increasing as shown in Fig. 3.



3.3. ABC Analysis

Fig.4 describes the ABC curve of Mumbai High area indicating the study area is moderately disturbed.

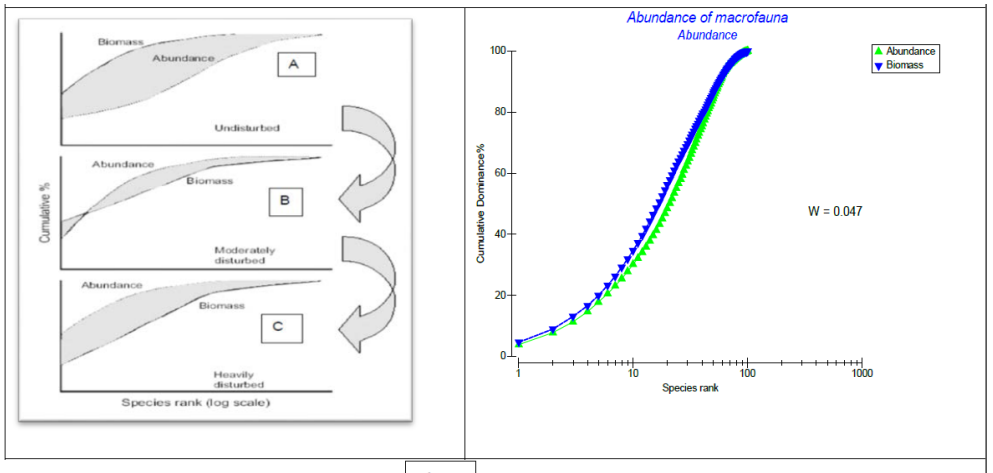


Fig.4

IV Conclusions

- The trend analysis (1994-2012) of contamination of sea sediments around the study area reveals that concentration of Lead is decreasing whereas Chromium, Nickel and Barium maintain almost a constant trend.
- Whatever the international findings are available, concentration of the metals around the study area is well comparable. (Table no.1)
- As such no permissible limits for the hydrocarbon content in sediments are documented, but the PHC content in most of the sediments of the study area are comparable to the literature values of other oceans. (Table no.2)
- The increasing trend of hydrocarbon content in sediments around most of the installations give a signal to adopt better discharge practices.
- Again, the behaviour of ABC curve for entire Mumbai High area, the area is moderately disturbed for benthic community.

Table I: Heavy Metal concentration (µg/g) in the sediments from various parts of the world

Area	Pb	Ni	Cr	Reference
Hong Kong Coast	9-260	5-220	5-560	F Zhou *et al* (2007)
Gulf Saudi Arabia	60-402	3.7-116.1	2.0-87	Sadiq. M(1985)
Gulf Kuwait Bay	17-48	149.5-209.1	148.9-204.3	Anderlini *et al* (1982)
North Sea , UK	17-238	6.5-220	0.4-41	Shiber *et al* (1979)
Narangansett Bay, USA	17-81	53-168	13-81	Eisler *et al* (1977)

Table II: Values of PHC in various sea sediments

Area	Survey year	Total Petroleum hydrocarbons(µg/g)	Reference
Saudi Arabia, Gulf	1991–1993	11-6900	Readman et al. (1996)
Kuwait, Gulf	1992–1993	40–240	Readman et al. (1996)
Xiamen Harbour, China	1993	3.1–33a	Hong et al. (1995)
Victoria Harbour, Hong Kong	1992	60–646a	Hong et al. (1995)
Western Coast, Taiwan	1990	869–10300a	Jeng and Han (1994)
Rhone River, France, Mediterranean Sea	1985–1986	25–170	Bouloubassi and Saliot (1993)
Kuwait, Gulf	1991	28	Fowler et al. (1993)
Saudi Arabia, Gulf	1991	19–671	Fowler et al. (1993)
Great Barrier Reef, Australia	1984	0.5–2	Volkman et al. (1992)
New York Bight, USA	1971–1975	35–2900	Farrington and Tripp (1977)
Black Sea	1988–1990	7–153a	Wakeham (1996)

V References

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