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Analysis of Heavy Metals (Cd, Pb) in Fish: A Case Study of the Western Offshore Region of ONGC

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Abstract—*ONGC, as a responsible social corporate company, recognizes the importance of long-term environmental monitoring of the marine area, where exploration and production of oil and gas takes place. Institute of Petroleum Safety, Health and Environment Management (IPSHEM), a committed arm of ONGC for promoting higher standards of health, safety and environment management in the Petroleum Sector, has thus been conducting environmental monitoring both around western and eastern offshore regions.*

This paper aims to investigate heavy metal (namely, cadmium and lead) concentration in the fish samples collected from the western offshore region in the period 2016-2018. Cadmium and Lead are highly toxic metals and good indicators of marine pollution levels, especially in fish, due to bioaccumulation. The paper also compares the heavy metal concentrations obtained with the toxicity limits stipulated by FAO and WHO. Cd and Pb found in the fish samples are well below the toxicity limit.

This study is useful, not only in checking the current pollution level, but also generating a data bank for a trend analysis over time which in turn will help in formulating environmental policies and sustainable exploration activities.

1. INTRODUCTION

Fish are good bio-monitors of pollution in the marine ecosystem [1]. Heavy metals once ingested by fish, get accumulated in their organs and tissues, known as bioaccumulation, eventually leading to biomagnification. These heavy metals maybe naturally occurring in trace quantities but are increased in the marine ecosystem mainly due to anthropogenic activities, those of the oil industry being one of the leading ones. Hence, monitoring this heavy metal concentration in fish tissues helps in assessing the marine pollution levels.

In this study, the heavy metals selected are – Cadmium and Lead, both non-essential heavy metals with no known biological importance [2]. Cadmium (Cd), is a non-degradable toxin. It is a known human carcinogen and may lead to oxidative stress, renal failure and softening of bones. Lead (Pb) is one of the most hazardous heavy metals, known to attack the brain and the central nervous system.

This paper describes the fish sampling around the western offshore region and heavy metal analysis methodology, in the years 2016-17 and 2017-18. The metal concentrations so obtained have been compared with the maximum permissible limit set by Food and Agriculture Organization of United Nations (FAO) and World Health Organization (WHO) in Codex-Stan 193-1995.

2. STUDY AREA

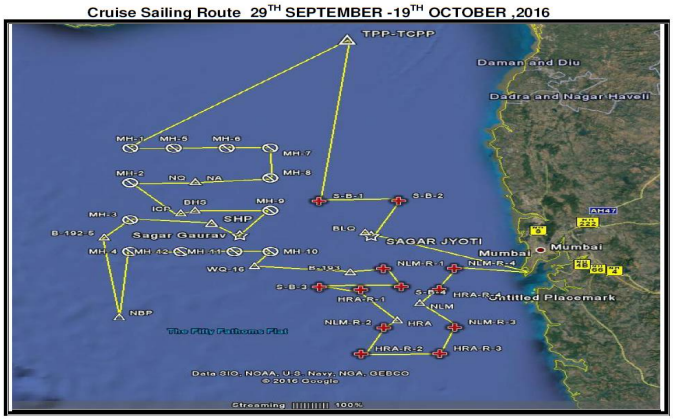

Figure 1: Sampling locations in 2016-17

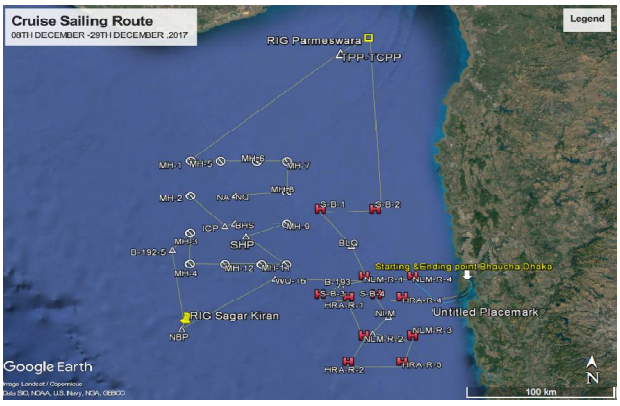

Figure 2: Sampling locations in 2017-18

13 ONGC installations were selected, off the western coast of India - Heera, Neelam, NA, NQ, ICP, BHS, BLQ, SHP, B-193, NBP, TPP-TCPP, WO-16 and B-192-5. The sampling station locations and their bearings around each installation in Bombay High and satellite fields as well as around the two drilling rigs and reference points are shown in **Figures 1 and 2** for the financial years 2016-17 and 2017-18 respectively. The exact coordinates of the locations have been attached as **Appendices 1 and 2**.

3. SAMPLING METHODOLOGY

All fishing operations are banned in the oil field area and their surroundings. Collection of fish samples was done by the standard method of bottom trawling. Such operations are not safe in the vicinity of production areas because of submerged pipelines and structures. Hence, to have a safe margin from pipelines and structures, fishing was done around 10-15 km away from the installations. Further, the fish population being highly mobile, the collection of fish samples in the adjoining areas of the operational field is an approximate estimation of distribution and abundance of fish fauna in the operational area and hence a distance of 10-15 km really does not matter. Also, distribution and abundance of fast swimming organisms like finfishes varies greatly in space and time. Although desirable, it is not physically possible to catch and analyze the same species in different seasons. Hence, samples of fish were collected using a bottom trawl net 10 – 15 km away from the installations of Bombay High. Fishing was done at few locations by using gillnet. Samples of fish and fish tissues were collected onboard in aluminum foils and polythene bags and stored at -20℃ for subsequent determination of heavy metals in the laboratory.

Figure 3: Fish samples

4. LABORATORY ANALYSIS

Microwave digestion of the collected fish samples was carried out as per the standard method EPA 3052 using concentrated acids, HNO_3, $HClO_4$ and HCl. Since the concentration of heavy metals in fish tissues is very low (usually in the range of ppb to ppm), accurate determination of their concentration is a very delicate and cumbersome task. The analytical methods using normal flame atomic absorption cannot detect the low concentrations of heavy metals and may not give reproducible results. Hence, all samples were analyzed using Agilent 7700 series Inductively Coupled Plasma Mass Spectrometer (ICP-MS) available at IPSHEM. These methods were standardized and accurately calibrated using standard metal solutions and standard reference samples.

5. RESULTS

The results obtained have been summarized in **Tables 1 and 2**. They give the Cd and Pb concentrations in the fish tissues sampled from the mentioned stations in mg/kg. Due to technical difficulties, all stations could not be sampled.

Table 1: Cd and Pb concentrations in mg/kg in 2016-17

Station	111 Cd	208 Pb
BLQ	0.03	0.03
SHP	0.02	0.02
ICP	0.03	0.01
NA	0.03	0.02
NQ	0.02	0.01
0NBP	0.06	0.02
TCP	0.05	0.02
MHRF	0.02	0.02

Table 2: Cd and Pb concentrations in mg/kg in 2017-18

Station	111 Cd	208 Pb
NLM	0.11	0.01
BLQ	0.12	0.01
SHP	0.10	0.02
NA	0.11	0.01
NQ	0.08	0.13
NBP	0.02	0.04
TCPP	0.05	0.02
RIG SAGAR KIRAN	0.02	0.01
RIG PARAMESHWAR	0.08	0.01
MHRF	0.46	0.01

The average Cd concentration observed around Mumbai High was 0.03mg/kg of the fish in 2016-17 and 0.12mg/kg in 2017-18. The average Pb concentration observed was 0.02mg/kg in 2016-17 and 0.03mg/kg in 2017-18.

6. DISCUSSION

The average concentrations of Cd and Pb obtained have been compared with the maximum permissible limit set by FAO and WHO in Codex Stan 193-1995 [3], as shown below in **Table 3**. **Table 4** shows WHO recommended weekly intake of the metals in mg per person per week [4].

Table 3: Comparison of average Cd and Pb concentration with the maximum permissible limit

Metal	2016-17 (mg/kg)	2017-18 (mg/kg)	Maximum Permissible Limit (mg/kg)
Cd	0.03	0.12	0.05-0.25
Pb	0.02	0.03	0.3

Table 4: WHO specifications of weekly intake of Pb and Cd

Metal	WHO Weekly intake mg per person per week
Cd	0.4-0.5
Pb	3

As it is evident from **Table 3**, the average concentrations of Cd and Pb have increased from 2016-17 to 2017-18. However, they are still within the permissible limit.

7. CONCLUSION

Thus, this paper discusses and compares Cd and Pb concentration in fish samples around Bombay High with the maximum permissible limits set by FAO and WHO. It is clear that offshore E&P activities of ONGC has not alarmingly polluted the marine ecosystem. However, an increasing trend in the metal concentrations is observed, which needs to be arrested. The future E&P activities have to be planned, keeping in mind sustainability of the marine life.

8. ACKNOWLEDGEMENTS

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[3] Codex Alimenterious - International Food Standards (1995)
[4] World Health Organization Technical Reports Series No. 505, FAO Nutrition Reports No. 51.

Appendix 1: Sampling location coordinates 2016-17

#	Installation	CODE	Coordinates	
1	**Operational Platforms**	**HRA**	N 18034'62'	E 72014'45"
2		**NLM**	N 18042'28'	E 72020'29"
3		**BLQ**	N 19012'28'	E 72006'45"
4		**NA**	N 19034'25'	E 71021'54"
5		**NQ**	N 19034'25'	E 71021'54"
6		**SHP**	N 19016'40'	E 71025'62"
7		**ICP**	N 19020'50'	E 71018'00"
8		**BHS**	N 19022'20'	E 71021'40"
9		**B193**	N 18055'35'	E 72002'29"
10		**NBP Field**	N 18036'09'	E 71001'40"
11		**B192-5**	N 19010'37'	E 70057'43"
12		**WO-16**	N 18058'16'	E 71037'18"
13		**TPP-TCPP**	N 20036'3.2'	E 72002'10.2"
1	**Rigs**	**Sagar Gaurav**	N 19011'13"	E 71033'23"
2		**Sagar Jyoti**	N 19011'05"	E 72008'04"
1	**Mumbai High Reference points**	**MHRF-1**	N 19048'55"	E 71004'30"
2		**MHRF-2**	N 19034'00"	E 71004'30"
3		**MHRF-3**	N 19018'00"	E 71004'30"
4		**MHRF-4**	N 19004'20"	E 71004'30"
5		**MHRF-5**	N 19048'55"	E 71016'00"
6		**MHRF-6**	N 19048'55"	E 71030'00"
7		**MHRF-7**	N 19048'55"	E 71041'30"
8		**MHRF-8**	N 19036'00"	E 71041'30"
9		**MHRF-9**	N 19022'00"	E 71041'30"
10		**MHRF-10**	N 19004'20"	E 71041'30"
11		**MHRF-11**	N 19004'20"	E 71032'00"

12		**MHRF-12**	N 19004’20”	E 71018’00”
13	**South Basin**	**S-Basin-1**	N 19026’00”	E 71054’30”
14		**S-Basin-2**	N 19026’00”	E 71054’30”
15		**S-Basin-3**	N 18049’00”	E 71054’30”
16		**S-Basin 4**	N 18049’00	E 72016’00”
17	**Neelam basin**	**Satellite N-1**	N 18056’50	E 72011’20”
18		**Satellite N-2**	N 18031’20	E 72011’20”
19		**Satellite N-3**	N 1803120	E 72030’00”
20		**Satellite N-4**	N 18056’50	E 72030’00”
21	**Heera Basin**	**Satellite H-1**	N 18047’45	E 72005’20”
22		**Satellite H-2**	N 18020’00	E 72005’20”
23		**Satellite H-3**	N 18020’00	E 72026’00”
24		**Satellite H-4**	N 18047’45	E 72026’00”

Appendix 2: Sampling location coordinates 2017-18

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11		**B192-5**	N 19010’37’	E 70057’43”
12		**WO-16**	N 18058’16’	E 71037’18”
13		**TPP-TCPP**	N 20036’3.2’	E 72002’10.2”
1	**Rigs**	**RIG SAGAR KIRAN**	N 18036’09.9’	E 71001’38.9”
2		**RIG PARAMESWARA**	N 20042’16.8’	E 72012’49.3”
1	**Mumbai High Reference points**	**MHRF-1**	N 19048’55”	E 71004’30”
2		**MHRF-2**	N 19034’00”	E 71004’30”
3		**MHRF-3**	N 19018’00”	E 71004’30”
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