Global Journal of Engineering and Technology Advances

eISSN: 2582-5003

Cross Ref DOI: 10.30574/gjeta

Journal homepage: https://gjeta.com/

(RESEARCH ARTICLE)

Check for updates

Heavy metal concentration in marine water: An assessment of ONGC's blocks in Mumbai High Region, Arabian Sea

Pallab Samanta *, N.N Ray and Sanjeev Singhal

Environment Division, Institute of Petroleum Safety, Health and Environment Management, ONGC, India.

Global Journal of Engineering and Technology Advances, 2024, 21(02), 070–078

Publication history: Received on 21 September 2024; revised on 28 October 2024; accepted on 30 October 2024

Article DOI: https://doi.org/10.30574/gjeta.2024.21.2.0197

Abstract

Heavy metal pollution, in the aquatic ecosystem, has become an area of concern garnering increasing attention since the past few decades. Some metals like manganese (Mn), copper (Cu), iron (Fe) and zinc (Zn) are biologically important for marine life. Other non-essential metals like lead (Pb), cadmium (Cd), and Arsenic (As) become toxic at higher concentrations. These metals are introduced into the marine ecosystem mainly due to anthropogenic activities. Hence, monitoring the heavy metal concentrations in these marine water over a period of time is of great help in checking the pollution level and identifying the trend, which in turn will be instrumental in formulating sustainable practices.

The paper mainly focuses on the study of the concentration of lead (Pb), cadmium (Cd), and Arsenic (As) in sea water around the operational areas of ONGC in Waestern offshore. The distribution of heavy metals in the seawater of ONGC's exploratory blocks in Mumbai High Region, Arabian Sea was studied. Fifty four sea water samples were collected as per OSPAR Commission guidelines from each blocks (Block A, Block B, Block C, Block D and Block E) of Mumbai High Region, Arabian Sea and processed samples were analyzed by ICP-MS for Pb, As, and Cd. Comparison of average results in studied 5 blocks with various seawater quality guidelines is discussed to assess the present level of contamination. The study reveals that seawater in study area is not contaminated with respect to perceived heavy metals. Generated data will assist in future for proactive measures to minimize the impact of anthropogenic sources.

Keywords: Heavy metal pollution; E and P activities; Mumbai High Region; Seawater Quality Guidelines

1. Introduction

Government of India started encouraging upstream hydrocarbon industry to enhance the domestic oil and gas production to shrink import encumbrance. World-wide experiences with updated technology have proven that offshore regions have great potential for exploration and production (EandP) activities. These EandP activities, include exploration, development, production and transportation of hydrocarbons may have adverse impact on marine environment. Oil and Natural Gas Corporation Limited (ONGC), accounts for two third of India's total oil and gas production, has an environment protection policy under which environmental monitoring study is carried out in its operational areas including exploratory blocks of the Mumbai High Region, Arabian Sea. Present paper deals with the concentration of heavy metals Pb, As and Cd in the seawater of five ONGC's blocks (Block A, Block B, Block C, Block D and Block E) of Mumbai High Region, Arabian Sea.

Marine environmental pollution is a worldwide problem and heavy metals belonging to the important pollutants. They are intrinsic, natural constituents of aquatic environment in small concentrations. In oceans, they originate from both natural processes and anthropogenic activities. Natural processes like soil erosion around mangrove forests, atmospheric inputs and aeolian processes set the background values whereas anthropogenic inputs, rapid

* Corresponding author: Pallab Samanta.

industrialization and urbanization in coastal regions, are the main sources of pollution in the marine environment. Heavy metals are also increasingly introduced to the coastal environments through oceanic dumping and riverine discharge where rivers that flow via high-populated urban areas may carry these substances to the downstream. It is difficult to remove them completely from the marine environment once they enter into it.

The study of heavy metals in the aquatic environment has attracted more attention in comparison with other pollutants due to their non-biodegradable nature, accumulative properties and long biological half-lives. They also pose potential threats to ecosystems because they could be concentrated and biomagnified at sufficiently high concentrations, and partly converted to more toxic organic compounds. Many of these metals tend to remain in the ecosystem and eventually move from one compartment to the other within the food chain.

In this paper, analysis of the concentration of three heavy metals Pb, As and Cd has been done in marine water of ONGC's five Blocks (Block A, Block B, Block C, Block D and Block E), in Mumbai High Region, Arabian Sea, from the year of 2022.

The study is intended to determine the present level of three heavy metals, (Pb, As and Cd) concentrations in seawater of ONGC's five Blocks (Block A, Block B, Block C, Block D and Block E) in Mumbai High Region, Arabian Sea. Pollution status of collected seawater was assessed by comparing average value of heavy metals, (Pb, As and Cd) with different quality guidelines of marine as well as drinking water. The results of this study, can be considered base-line data and will help for proactive measures to manage and control pollution in coastal region. Thus, study is vital so that any change caused by anthropogenic sources over a period of time can be monitored and managed.

1.1. Study Area

Mumbai High Region, Arabian Sea is considered significant address for oil and gas reserves. Subsequently, offshore EandP activities have been started on Indian east coast nearly two decades ago by public and private operators as well.

2. Materials and Methods

2.1. Sample Collection and Pre-treatment

Niksin sampler was used for sampling of heavy metals from the sub surface, middle and above bottom sample. These bottles are non-metallic, free-flushing sampler recommended for general purpose water sampling. During the sampling this plastic cylinder, was lowered to the desired depth with both ends open. Closure of the cylinder was usually triggered by a mechanical messenger. In Niksin sampler, top and bottom cap are held open by a clamp against the tension of a rubber string connecting through the cylinder. The action of the messenger release clamp and caps are pulled into a position closing off top and bottom of the cylinder by retaining the water column in the cylinder from the depth and time of closure. This water can be retrieved without any contamination from the upper lying water column. As soon as the field work was finished, water samples were carefully shipped and preserved at laboratory.

2.2. Laboratory Analysis

Trace metal extraction is carried out following the standard method APHA- 23rd Ed. 3111B.

2.2.1. Preparation of sample for V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, Ba, and Pb :

- Transfer 50.0 ml of well-mixed, acid-preserved sample appropriate for expected metals concentrations to a flask or beaker.
- In a hood, add 2.5 ml concentrated Nitric acid. If beaker is used, cover it with ribbed watch glass to minimize the contamination.
- Boiling chips or glass bead were be added to aid boiling and minimizing spatter when high level (>10mg/L) concentrations are being determined.
- Bring to a slow boil and evaporate on a hot plate to the lowest volume possible (about 10 to 20ml) before precipitations occur.
- Continue heating and adding concentrated HNO_3 as necessary until digestion is complete, as shown by a light coloured clear solution.
- Do not let sample dry during digestion. Wash down flasks or beaker walls and watch glass cover (if used) with metal –free water and then filter with 42 filter paper.
- Transfer filtrate to 50 ml volumetric flask. Cool, dilute to the mark and mix thoroughly. Take portion of this solution for metal determination.

2.2.2. Preparation of sample for Arsenic.

- Add 50.0 ml sample to 250.0 ml in Kjeldahl flask.
- Add 7.0 ml 18 N H_2SO_4 and 5.0 ml conc. HNO_3.
- Add small boiling chips or glass beads if necessary. Evaporate to SO_3 fumes.
- Maintain oxidizing conditions at all times by adding small amounts of HNO3 to prevent solution from darkening.
- Maintain an excess of HNO_3 until all organic matter is destroyed. Complete digestion is usually indicated by light colour solution.
- Cool slightly, add 25 ml water and 1.0 ml $HCLO_4$ and again evaporate to SO_3 fumes to expel oxides of nitrogen.
- After final evaporation of SO_3 fumes, filter with 42 filter paper and dilute to 50.0 ml with distilled Water.

In order to obtain accurate data, all the glassware and teflon sample cups in this study were soaked with 5% nitric acid, rinsed with milli-Q water, and dried to eliminate potential contamination. An inductively coupled plasma mass spectrometer (ICP-MS; model Agilent 7700) was used for determination of trace metals concentration. Background correction and matrix interference were monitored throughout the analysis. The accuracy was examined by analysing all samples in duplicate. The analytical concentrations of the selected metals of our interest are listed in Table 2.

Table 1 Average metal concentration in ppb (µg/l) of each blocks

Station	Pb	Cd	As
Block A	0.26	0.04	1.59
Block B	0.00	0.03	1.59
Block C	0.09	0.02	0.69
Block D	0.00	0.05	2.36
Block E	0.04	3.16	9.38

Table 2 Comparison of average concentration heavy metals obtained in this research with water Quality Guidelines

Heavy Metals	USEPA,2008* (µg/l)	WHO,2008* (µg/l)	EU,1998* *(µg/l)	BIS (ISO: 10500,2012)* (µg/l)	ANZECC 2000** (µg/l)	MMWQCS***	Present Study (µg/l)
Pb	15	10	10	10	7	50	0.00-0.26
As	10	10	10	10	30	50	0.69-9.38
Cd	5	3	5	3	5	10	0.02-3.16

*Assessment of Heavy Metal Pollution in Water Resources and their Impacts: A Review by Priti Saha1 and Biswajit Paul2; ** Australian and New Zealand Environment and Conservation Council; *** Malaysia Marine Water Quality Criteria and Standard (Class 3)

OSPAR (Oslo and Paris) Commission Guidelines [3] have been followed, as shown in Figure 1.

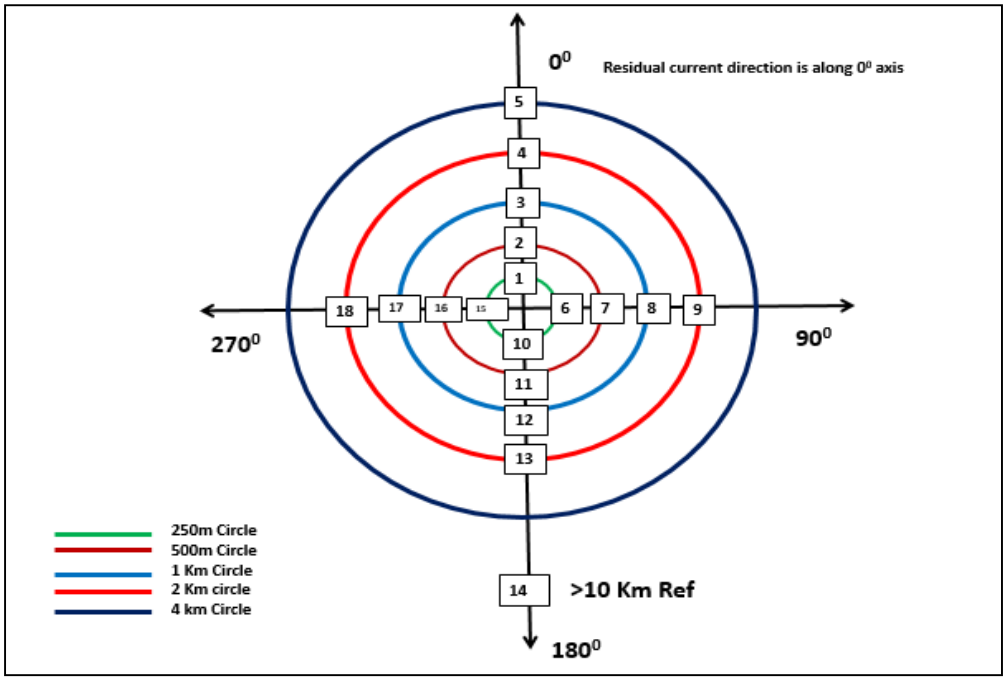

Figure 1 OSPAR Commission Sampling Strategy

3. Results and Discussion

In this study, the concentrations of Lead (Pb), Cadmium (Cd), and Arsenic (As) in seawater were measured in five Blocks (Block A, Block B, Block C, Block D and Block E) in Mumbai High Region (Table 2).

The study shows that concentration of heavy metals in the studied five Blocks (Block A, Block B, Block C, Block D and Block E) varied from 0.00-0.26 µg/l for Lead, 0.02-3.16 µg/l for Cadmium, and 0.69-9.38 µg/l for Arsenic. It is noticed that the distribution of metal concentrations in the seawater of study area does not show any particular trend as concentration varied from one location to another but variation is found minimum when area, depth, and other oceanographic parameters are taken into account. It is also observed that all measured metals were found nearly uniformly distributed across all the sampling sites.

These concentrations of metals in the study were compared with water quality guidelines to assess present marine pollution status with respect to perceived metals and impact of industrial and economic activities in this area. Table 3 shows guidelines used in present study; water criteria proposed by USEPA, WHO, EU, BIS (ISO: 10500, 2012), ANZECC (*Australian and New Zealand Environment and Conservation Council*), and MMWQCS (*Malaysia Marine Water Quality Criteria and Standard (Class 3)* for heavy metals contents in marine seawater.

It is observed that metal contents in seawater samples are falling under non-polluted category with respect to analysed metals. Observed relative lower values could be caused due to high turbulence, which basically restrict the accumulation of trace metals into the seawater. Therefore, it may be concluded that studied seawater is not contaminated with Pb, Cd and As. Though the precise source of current metal inputs in the study area is accurately unknown and, hence requires further research. However, observed concentrations are believed to have perhaps been enriched through natural processes, industrial activities around the study area and polluted river water influx.

The results of this study supply valuable data about the metal contents in seawater from different ONGC's blocks in Mumbai High Region, Arabian Sea. This can be considered as a bio-indicator of the environmental contamination in this zone by estimating the bioavailability of metals to the marine biota.

Table 3 Heavy Metals Cocentration in ppb (µg/l) in collected Seawater sample as per OSPAR guidelines of different blocks

DIRECTION	DISTANCE (MTR)	DEPTH	HEAVY METALS IN SEDIMENTS (all values in mg kg^{-1} or µg/g)														
			BLOCK A			BLOCK B			BLOCK C			BLOCK D			BLOCK E		
			^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb
EAST	250	S	1.16	0.02	0.07	1.66	0.01	0.00	1.12	0.01	0.06	1.37	0.02	0.00	16.43	9.20	0.27
	250	M	1.30	0.05	0.06	1.72	0.02	0.00	0.76	0.04	0.00	1.18	0.02	0.00	18.26	8.37	0.00
	250	B	1.27	0.08	0.52	2.40	0.00	0.00	0.97	0.01	0.44	1.73	0.06	0.00	18.87	7.53	0.27
	500	S	1.09	0.01	0.00	1.88	0.03	0.00	0.67	0.04	0.15	1.56	0.03	0.00	16.43	6.97	0.00
	500	M	1.15	0.00	0.46	2.11	0.03	0.00	0.75	0.02	0.00	1.45	0.02	0.00	17.04	5.58	0.00
	500	B	1.22	0.08	0.87	2.29	0.04	0.00	1.33	0.00	0.28	1.49	0.05	0.00	22.52	8.92	0.10
	1000	S	0.96	0.00	0.00	1.96	0.02	0.00	1.10	0.01	0.11	1.22	0.03	0.00	8.52	7.81	0.00
	1000	M	1.22	0.01	0.18	2.22	0.06	0.00	0.86	0.03	0.00	1.62	0.05	0.00	15.22	8.37	0.16
	1000	B	0.85	0.06	0.31	2.09	0.02	0.00	1.10	0.01	0.51	1.46	0.03	0.00	20.69	4.46	0.18
	2000	S	1.10	0.01	0.00	2.45	0.04	0.00	0.47	0.04	0.08	1.46	0.01	0.00	17.04	6.69	0.09
	2000	M	0.00	0.00	0.00	2.07	0.03	0.00	1.01	0.05	0.00	1.31	0.03	0.00	23.74	6.13	0.00
	2000	B	1.09	0.08	0.00	2.43	0.00	0.00	1.41	0.01	0.44	1.52	0.05	0.00	31.04	10.32	0.21

Table 4 Heavy Metals Concentration in ppb (µg/l) in collected Seawater sample as per OSPAR guidelines of different blocks

DIRECTION	DISTANCE (MTR)	DEPTH	HEAVY METALS IN SEDIMENTS (all values in mg kg^{-1} or µg/g)														
			BLOCK A			BLOCK B			BLOCK C			BLOCK D			BLOCK E		
			^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb
WEST	250	S	1.02	0.08	0.27	2.21	0.06	0.00	1.19	0.00	0.06	1.50	0.02	0.00	10.35	7.53	0.07
	250	M	1.46	0.02	0.09	2.03	0.02	0.00	0.80	0.02	0.00	1.06	0.09	0.00	10.35	10.60	0.11
	250	B	1.03	0.10	0.19	2.22	0.04	0.00	1.01	0.01	0.08	1.30	0.07	0.00	13.39	2.51	0.21
	500	S	1.16	0.00	0.00	1.98	0.03	0.00	0.80	0.01	0.07	1.58	0.04	0.00	21.91	6.41	0.00
	500	M	0.96	0.00	0.70	2.42	0.01	0.00	1.01	0.05	0.00	1.39	0.02	0.00	24.95	5.58	0.00
	500	B	1.43	0.09	0.35	2.41	0.03	0.00	2.41	0.01	0.69	1.40	0.07	0.00	21.30	6.97	0.01
	1000	S	1.44	0.03	0.00	2.05	0.07	0.00	1.06	0.00	0.16	1.69	0.03	0.00	23.13	4.46	0.00
	1000	M	0.64	0.01	0.02	2.03	0.03	0.00	0.91	0.03	0.00	1.42	0.03	0.00	11.56	9.76	0.00
	1000	B	1.08	0.02	0.00	2.57	0.02	0.00	3.48	0.07	1.23	1.36	0.05	0.00	24.35	5.02	0.00
	2000	S	1.77	0.04	0.12	2.22	0.07	0.00	0.69	0.02	0.01	1.50	0.03	0.00	25.56	6.41	0.17
	2000	M	1.13	0.01	0.00	1.77	0.02	0.00	0.83	0.02	0.00	1.23	0.04	0.00	30.43	8.37	0.11
	2000	B	1.10	0.05	0.11	2.10	0.05	0.00	0.73	0.02	0.15	1.42	0.06	0.00	21.91	6.13	0.19

Table 5 Heavy Metals Concentration in ppb (µg/l) in collected Seawater sample as per OSPAR guidelines of different blocks

DIRECTION	DISTANCE (MTR)	DEPTH	HEAVY METALS IN SEDIMENTS (all values in mg kg^{-1} or µg/g)														
			BLOCK A			BLOCK B			BLOCK C			BLOCK D			BLOCK E		
			^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb
NORTH	250	S	0.49	0.02	0.00	1.19	0.02	0.00	0.57	0.01	0.07	1.77	0.09	0.00	1.52	0.00	0.00
	250	M	0.55	0.00	0.02	0.86	0.06	0.00	0.75	0.04	0.00	2.21	0.05	0.00	1.84	0.00	0.00
	250	B	0.85	0.08	0.05	1.24	0.04	0.00	0.37	0.03	0.00	2.13	0.09	0.00	1.29	0.01	0.00
	500	S	1.12	0.00	0.04	1.05	0.03	0.00	0.41	0.03	0.00	2.47	0.04	0.00	1.53	0.03	0.00
	500	M	0.42	0.03	0.57	1.10	0.06	0.00	0.32	0.02	0.00	2.35	0.07	0.00	1.58	0.00	0.00
	500	B	1.30	0.02	0.07	1.16	0.03	0.00	0.62	0.02	0.21	2.61	0.08	0.00	1.17	0.01	0.00
	1000	S	1.42	0.01	0.00	1.13	0.03	0.00	0.38	0.01	0.00	2.42	0.06	0.00	1.35	0.02	0.00
	1000	M	2.21	0.03	0.34	1.16	0.04	0.00	0.41	0.02	0.00	2.09	0.06	0.00	1.45	0.00	0.00
	1000	B	1.62	0.02	0.62	1.26	0.01	0.00	0.57	0.02	0.19	2.50	0.09	0.00	1.38	0.00	0.00
	2000	S	2.03	0.02	0.13	0.86	0.03	0.00	0.27	0.01	0.00	3.14	0.02	0.00	1.15	0.00	0.00
	2000	M	1.50	0.01	0.18	1.16	0.04	0.00	0.38	0.01	0.00	3.06	0.05	0.00	1.14	0.00	0.00
	2000	B	1.98	0.05	0.48	1.13	0.02	0.00	0.30	0.01	0.00	2.91	0.04	0.00	1.51	0.03	0.00

Table 6 Heavy Metals Concentration in ppb (µg/l) in collected Seawater sample as per OSPAR guidelines of different blocks

DIRECTION	DISTANCE (MTR)	DEPTH	HEAVY METALS IN SEDIMENTS (all values in mg kg^{-1} or µg/g)														
			BLOCK A			BLOCK B			BLOCK C			BLOCK D			BLOCK E		
			^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb	^{75}As	^{111}Cd	^{208}Pb
SOUTH	250	S	2.18	0.01	0.14	1.24	0.03	0.00	0.34	0.01	0.00	3.38	0.03	0.00	1.54	0.02	0.00
	250	M	2.97	0.03	0.56	1.36	0.02	0.00	0.38	0.03	0.00	3.26	0.03	0.00	1.45	0.00	0.00
	250	B	2.55	0.12	0.96	1.76	0.03	0.00	0.58	0.00	0.00	2.84	0.09	0.00	1.54	0.05	0.00
	500	S	1.99	0.02	0.08	0.00	0.01	0.00	0.29	0.00	0.00	3.88	0.05	0.00	1.35	0.02	0.00
	500	M	1.96	0.00	0.11	1.36	0.01	0.00	0.28	0.00	0.00	3.48	0.03	0.00	1.18	0.03	0.00
	500	B	3.29	0.18	0.64	1.36	0.05	0.00	0.10	0.03	0.01	3.64	0.09	0.00	1.22	0.02	0.00
	1000	S	2.92	0.02	0.15	1.32	0.02	0.00	0.33	0.00	0.00	3.84	0.05	0.00	1.22	0.02	0.00
	1000	M	2.91	0.05	0.45	0.00	0.00	0.00	0.33	0.02	0.00	3.48	0.03	0.00	1.55	0.00	0.00
	1000	B	2.32	0.10	2.62	1.22	0.03	0.00	0.32	0.00	0.00	3.77	0.06	0.00	1.54	0.01	0.00
	2000	S	2.05	0.07	0.08	1.28	0.04	0.00	0.26	0.01	0.00	3.81	0.06	0.00	1.19	0.01	0.00
	2000	M	3.12	0.04	0.45	1.22	0.03	0.00	0.40	0.02	0.00	4.16	0.04	0.00	1.46	0.00	0.00
	2000	B	2.39	0.07	0.06	1.21	0.03	0.00	0.32	0.00	0.00	3.91	0.08	0.00	1.20	0.06	0.00

4. Conclusion

The results of present study that the concentrations of the three heavy metals As, Cd and Pb in seawater of 5 different ONGC's blocks (Block A, Block B, Block C, Block D and Block E) of Mumbai High Region, Arabian Sea are on absolutely lower side and well comparable with the reported values of available oceanographic scientific literature. This can be thought to have resulted from absence of significant anthropogenic influence around the study area. Based on the study, it can be inferred that the low contents of the heavy metals in the studied sea water samples, which are well within the internationally accepted norms, will not have any toxicological effects on human health, when sea food from this area is included in the diet. Therefore, seawater samples in present study area in Arabian Sea are not polluted with respect to heavy metals As, Cd and Pb however requires regular monitoring of heavy metal concentration in zones particularly zones, where industrial operations are planned.

Compliance with ethical standards

Acknowledgement

The authors are grateful to the ONGC's management for encouraging for preparation and presentation of this paper. They also wish to acknowledge Executive Director, Institute of Petroleum Safety, Health and Environment Management for his continuous guidance and support.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Assessment of heavy metals in seawater and fish tissues at Pulau Indah, Selangor, Malaysia, Sabarina Md Yunus, Zaini Hamzah, Ab. Khalik Wood and Ahmad, https://doi.org/10.1063/1.4916877

[2] Heavy Metal Concentration of Sea Water and Marine Organisms in Ennore Creek, Southeast Coast of India, C. Suresh Kumara, M. Jaikumar , Robin R.S, P. Karthikeyan , C. Saravana Kumar, The Journal of Toxicology and Health. Photon 103 (2013) 192-201.

[3] A Review of Heavy Metals in Water, Sediment and Living Organisms in the Black Sea, Boran M., Altınok N.,Turkish, Journal of Fisheries and Aquatic Sciences, 10, 565-572.

[4] Heavy Metals in Surface Water, Sediments, Fish and Perwinklesof Lagos Lagoon, O.J. Aderinola, et al, American-Eurasian J. Agric. and Environ. Sci., 5 (5): 609-617, 2009, ISSN 1818-6769.

[5] Sukalyan Chakraborty, et al, Benthic macroalgae as biological indicators of heavy metal pollution in the marine environments: A biomonitoring approach for pollution assessment, Ecotoxicology and Environmental Safety100 (2014)61–68.

[6] Pollution assessment in the aquatic ecosystem along the western coast of the Suez Bay, Egyp, Abou-El-Sherbini KhS, Hamed MA (2000), J. Aquat. Biol. Fish. 4(4):37-59.

[7] N. Balkıs, et al, Heavy metals in shallow sediments from the Black Sea, Marmara Sea and Aegean Sea regions of Turkey, J. Black Sea/Mediterranean Environment, Vol. 13:147-153 (2007).

[8] Assessment and management of heavy metal pollution in the marine environment of the Arabian Gulf: A review, Humood A. Naser, Marine Pollution Bulletin 72 (2013) 6–13.

[9] Heavy Metals Toxicity and the Environment, Paul B. Tchounwou, Clement G. Yedjou, Anita K. Patlolla, and Dwayne J. Sutton.

[10] Assessment of Heavy Metal Pollution in Water Resources and their Impacts: A Review by Priti Saha1 and Biswajit Paul2