

Quantification of Poly Aromatic Hydrocarbons in Waters of Mahanadi Estuary at Paradeep, Odisha

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Abstract - Polycyclic aromatic hydrocarbons (PAHs) are pervasive ecological toxins produced fundamentally during the deficient burning of natural materials (e.g. coal, oil, petrol, and wood). Outflows from anthropogenic exercises prevail; by and by, some PAHs in the earth start from regular sources, for example, open consuming, normal misfortunes or leakage of oil or coal stores, and volcanic exercises. Major anthropogenic wellsprings of PAHs incorporate private warming, coal gasification and melting plants, carbon dark, coal-tar pitch and black-top creation, coke and aluminum creation, reactant breaking towers and related exercises in oil refineries and engine vehicle fumes. Surface seawater samples collected during the study from 06 stations around Mahanadi estuary have been analyzed for 16 individual parents PAH compounds, using Gas chromatography mass spectrometry (GC-MS). The sampling sites included estuarine, coastal and offshore locations. PAH concentrations at offshore sites were generally low. Higher concentrations were found in many riverine and estuarine samples, with PAH concentrations ranging from 0.9 ppb to 6.2ppb much higher than the prescribed standard. Particularly high concentrations of PAH were detected close to a steel manufacturing plant (ESAR steel) on the River Mahanadi, predominantly in the dissolved phase. The PAH concentrations though not sufficiently high to pose a risk of immediate mortality in exposed organisms, but may have the potential to affect the long-term wellbeing of a range of aquatic organisms.

Key Words: Mahanadi estuary, Poly aromatic hydrocarbons (PAHs), Gas chromatography mass spectrometry (GC-MS).

1. INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are the organic compounds which are generally colorless, white, or light-yellow solids. They are a universal gathering of a few hundred artificially related mixes, ecologically constant with different structures and shifted harmfulness. They have toxic effect life forms through different activities. For the most part, PAHs enter nature through different courses and are generally found as a blend containing at least two of these mixes, e.g. soot. Some poly aromatic hydrocarbons are manufactured in the industry. The instrument of poisonousness is viewed as obstruction with the capacity of cell layers just as with protein frameworks which are related with the film. It has been demonstrated that PAHs can cause cancer-causing and mutagenic impacts and are intense

immunosuppressant. Impacts have been reported on invulnerable framework advancement, humeral invulnerability and on have obstruction [1,2]. PAHs can be framed both during organic procedures and as results of fragmented burning from either normal ignition sources (forest and brush fires) or man-made burning sources (car emanations and tobacco smoke). In this way, PAHs are generally identified in air, soil, and water. In this manner, PAHs are viewed as omnipresent in nature [3,4]. The pervasive idea of PAHs in the earth has been all around summed up by Menzie et al. [5].

The term "PAH" alludes to mixes comprising of just atoms of carbon and hydrogen. Chemically the PAHs are contained at least two benzene rings fortified in straight, cluster, or angular arrangements [6,7]. PAHs are semi-volatile compounds under environmental conditions. They move between the climate and the World's surface in rehashed, temperature-driven patterns of testimony and volatilization. Within the sight of daylight, PAHs experience photograph oxidation in the encompassing air, where they are available as fumes, or are assimilated into airborne particulate matter. Chemical breakdown because of photograph oxidation can take a few days to weeks; their essence in the climate is dependent upon complex physicochemical responses, photochemical changes, and responses with different contaminations. The widespread occurrence of PAHs is generally because of their arrangement and discharge in all procedures of deficient burning of natural materials. These tenacious adsorbed PAHs later debase soil and water frameworks. Microbial populaces in sediment or water frameworks corrupt some PAHs and diminish their poisonousness over some stretch of time. Aquatic organisms are mostly affected by PAHs metabolism and photo-oxidation; the presence of UV light usually increases toxicity. PAHs go into earthbound creatures by different courses, for instance, inward breath, dermal contact, and ingestion, while retention is the course of passage into plants from soil, that is, through their underlying foundations. Bioaccumulation of PAHs happens in plants, albeit certain plant species can orchestrate PAHs that go about as development hormones.

Since they are a moderate relentless contaminant in nature, the grouping of PAHs in marine creatures (fish and shellfish) is relied upon to be a lot higher than in the earth due to bio-magnification. PAHs dispersion through air and move through terrestrial and aquatic environments as a result of various processes. Sixteen PAHs have been identified as

being of greatest concern with regard to potential exposure and adverse health effects on humans and are thus taken as a group. Natural observing of introduction to PAHs is of essential enthusiasm, because of the across the board dispersion of these mixes and to their toxicological pertinence. Notwithstanding, the wellbeing impacts of individual PAHs are not actually similar. In fact, the Universal Office for Exploration on Malignant growth [8] orders some PAHs as known, perhaps, or likely cancer-causing to people (Group 1, 2A or 2B). Among these are benzo[a]pyrene (Group 1), naphthalene, chrysene, benzo[a]anthracene, benzo[b]fluoranthene (Group 2B) and benzo[k]fluoranthene [8]. Some PAHs are notable as cancer-causing agents, mutagens, and teratogens and in this way represent a genuine danger to the wellbeing and the prosperity of people. The most significant health effect to be expected from inhalation exposure to PAHs is an excess risk of lung cancer [9].

Chemical oxidation seems to be a negligible PAH degradation mechanism under most environmental circumstances. On account of concoction oxidation, either normally or as a major aspect of treatment innovations [11], the rates of PAH oxidation rely upon a few properties of the framework. The atomic weight and structure of exacerbate, its physical state, temperature, and the quality of the oxidizing operator all effect the result. It was accounted for that substance treatment and additionally physical treatment could expel PAHs productively from surface water depend on several properties of the system. The molecular weight and structure of the compound, its physical state, temperature, and the strength of the oxidizing agent all impact the outcome. It was reported that chemical treatment and/or physical treatment could remove PAHs efficiently from surface water [12]. Alebic-Juretic et al. reported that fluoranthene was the most stable of the PAHs tested for oxidation by ozone [13]. This could be one reason that why fluoranthene is often present in high concentrations in the soil information assessed. Zhang et al. additionally reported that the synergistic impact of UV illumination and TiO₂ or ZnO catalysis was proficient for corruption of PAHs in sullied soil [15,16]. Iron oxides and oxalic corrosive can set up a photograph Fenton-like framework without extra H₂O₂ in strong stage to upgrade the photodegradation of pyrene under UV light [14]. On the other hand, sono-chemical degradation of PAHs using high frequency of ultrasound was also investigated [17,18].

Dry deposition happens when PAHs sorbet to climatic particles settle to earth without precipitation as appeared in Fig. 1 [10,19-21]. Dry deposition rates vary depending on the specific properties of the PAHs, sorbent particle, and atmospheric conditions. For example, enormous particles will in general settle quicker than little particles since huge particles will in general be heavier than littler particles. Such heavier particles require more grounded environmental flows to keep them suspended when contrasted with little particles. Consequently, climatic condition is the most

significant factor influencing the pace of dry testimony. Besides, particles will settle quicker in a more tranquil environment than in a temperamental one on the grounds that the breeze and barometrical flows in an insecure air have enough vitality to keep particles from settling.

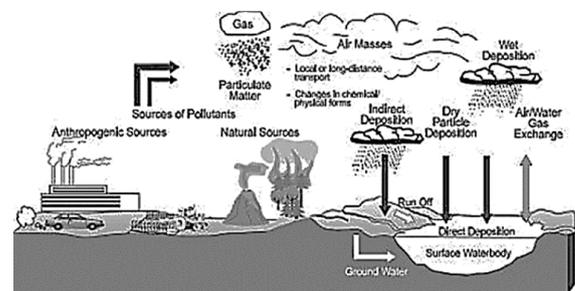
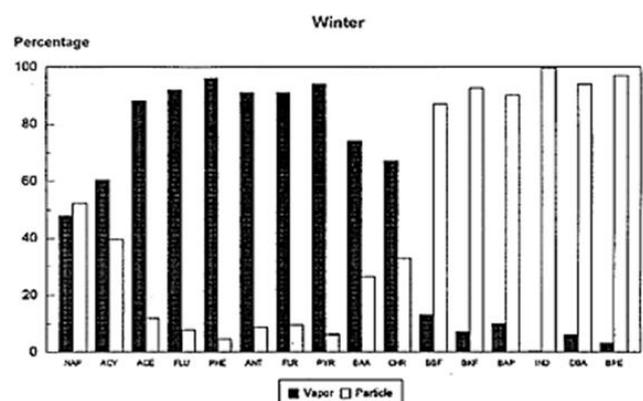


Fig.1: Removal of PAHs from atmosphere

Then again, temperature will likewise influence the rate at which PAHs are saved from the air. For example, higher temperatures will cause a greater fraction of the total PAHs to be in the vapor phase and lower temperatures will increase sorption of PAHs [22,23]. This phenomenon can be found in the molecule/fume PAH dispersions from winter to summer showed in Fig. 2 [24]. In this figure, the PAH mixes are appeared so the fume compels decline from left to directly on the x-axis. In accumulation, the y-axis as far as level of every individual PAH, as opposed to fixation, with the whole of the fume and particulate stages for each PAH compound signifying 100%. Fig. 2 evidently determines the effects of vapor pressure and temperature on the fume/molecule stage circulation of some PAHs. For example, about 93% of naphthalene was found in the vapor phase in air sampled in summer while only about 53% of naphthalene was in the vapor phase in air sampled during winter (Harrison et al., 1996).



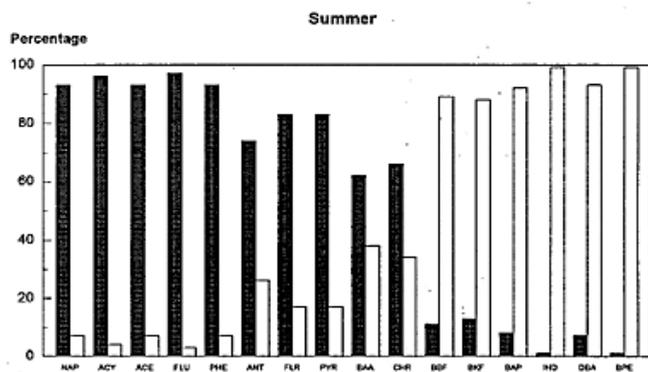


Fig. 2: Illustration of the particle/vapor PAH distributions from winter to summer [24]

However, for PAHs with extremely low fume pressures, for example, benzo(a)pyrene and dibenz(a,h)anthracene, there were no huge contrasts between the fume and particulate stage disseminations in either summer or winter. Hence, temperature will have a substantial impact on the concentrations and distribution of PAHs in the vapor or particulate phases [25,26].

Mahanadi river system is the 3rd largest in the peninsula of India & the largest river in Orissa state (which is located in the north-eastern coast of India having latitudes between 17°49' N & 22°34' N and longitudes between 81°27' E & 87°29' E). The basin extends over an area of approximate 141,600km², with a total length of 851km & peak discharge of 44,740m³s⁻¹ water.

Heavy industrial as well as agricultural activities are found in Mahanadi basin & in also in and around Paradeep. It also receives a large amount of agricultural run-off along on its course. The nutrient rich water after travelling all the distance enters the Bay of Bengal at Paradeep. A lot of work has been carried out on the water quality of the Mahanadi estuarine system, however, works on determining pesticides and herbicides in Estuary and Sea Water of Mahanadi, Near Paradeep is very few.

1.1 Hypothesis

As river Mahanadi is the largest river of Odisha, with maximum agricultural fields in its catchments must receive PAH and enters into the sea through its most fertile and ecologically rich, diversified estuarine ecosystem, might impart potential influence on it.

2. MATERIALS AND METHODOLOGY

2.1 Study area:

Paradeep is situated at East-coast region of odisha; this region is known for estuary of the river Mahanadi. Paradeep port and various large industries and refineries situated

around 14 km from beach like Iffco, Essar, Ioel, Kalinga Calciner, Skol Breweries Ltd, Cargill's Edible Oil Plant etc. The beach is famous for its clear blue water, green forest, stones alongside the beach, a good marine drive and the biggest port of Odisha. Paradeep Port is positioned between the latitude 20015'55044'N and longitude 86040'34062'E.

2.2 Site selection:

The sampling points are selected starting from upstream of river near shore up to 2.3 km toward sea, the selected sited are given below(Table 1 and Fig.3).

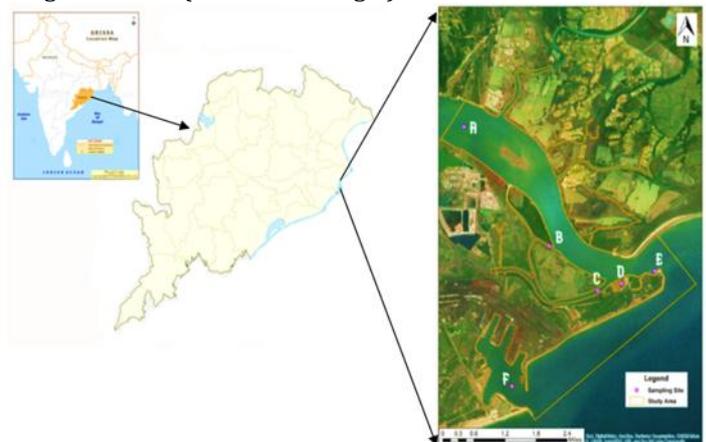


Fig. 3: Sampling points

Table 1: List of sampling points

CODING OF SAMPLING POINT	NAME OF SAMPLING POINT	COORDINATES
A	Mahanadi U/s	20°19'40.24"N / 86°39'44.97"E
B	IFFCo Channel	20°17'55.37"N / 86°41'10.47"E
C	AtharaBanki Creek	20°17'15.85"N / 86°41'59.34"E
D	Mahanadi Fishing Jetty	20°17'22.38"N / 86°42'23.15"E
E	Mahanadi Shore 1	20°17'33.35"N / 86°42'56.68"E
F	Paradeep port	20°15'51.99"N / 86°40'33.07"E

2.3 Sample collection:

The water sample is collected from surface (within 3feet) for the analysis of Poly Aromatic Hydrocarbon (PAH). The samples were collected using Teflon coated Niskin water sampler (avoid any form of metal contact with samples). Nearly two liters of water samples were collected amber

bottle to prevent direct exposure to sunlight, transported and kept in chill condition (i.e refrigerator or ice) till the samples arrive up to laboratory for extraction and further analysis.

2.4 Instrument used for Analysis Sample Extraction procedure:

Gas Chromatography using GC-MS (Make Thermo Scientific, Model: GC-1310, MS-TSQ8000, Auto sampler- Triplus RSH).

Sample Extraction procedure:

- Before analysis all lab-wares were cleaned with 0.2N HNO₃.
- 500ml sample taken (which we collect from sea or estuary).
- 25ml of Di-chloro-Methane was put into 500ml sample in Separatory funnel.
- Mixture was shaken for 12-15 min manually or by shaker machine.
- Air pressure were released intermittently.
- After shaking, the mixture was left for 1 min for clear distinct visible layers, with di-chloromethane on bottom.
- Then slowly bottom layer was removed and passed through sodium sulphate & collected for concentration and transfer in to n-Hexane (solvent).
- This process was repeated twice for complete extraction of the PAH.
- Collected Di- chloro-Methane was put into rotary evaporator and makes the sample concentrated to 1-1.5 ml.
- Now the sample was ready for injection into GC-MS for analysis.

2.5 Creating distribution map using Arc-GIS:

Step-1: GIS Database creation:

This is involving description of study boundary, extracting the data sampling points and parameters of those points. GIS database creation of thematic layers through line digitization from base map.

Step-2: Delineating the distribution of parameters:

This involves the IDW (Inverse Distance Weighting) method of geo-statically analyst tool. Through this the distribution of the parameters of the 6 different sampling points were derived.

Step-3: Exporting the Map:

This involves the exportation of all those 16 maps which shows the distribution.

3. RESULT AND DISCUSSION

Sixteen PAH species (Naphthalene, Acenaphthalene, 2-bromo naphthalene, Acenaphthene, Fluorine, Phenanthrene, Anthracene, Fluoranthene, Pyrenees, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(a)Pyrene, Indeno (1,2,3-cd)pyrene, Dibenz(a,h) Anthracene, Benzo(g,h,i) Perylene) were analyzed .

3.1 Distribution of different poly aromatic hydrocarbon (PAHs):

1. Naphthalene

Naphthalene is made from crude oil or coal tar. It is also produced when things burn, so naphthalene is found in cigarette smoke, car exhaust, and smoke from forest fires. It is used as insecticides and pest repellent. Naphthalene was first registered as a pesticide in the United States in 1948. It is also used as a fumigant insecticide that works by turning directly from a solid into a toxic vapor. Most naphthalene in the environment will turn into a gas. Some of it may be bound to soil, where it can be taken up by plants. It can also be deposited on plants. It can be taken up by plants. It can also be deposited on plant leaves from the air. Naphthalene is broken down by bacteria, fungi, air, and sunlight. Naphthalene has been found in wastewater treatment plant discharge. It is found that naphthalene varies from 0.9 ppb (site D) to 3.2 ppb (at site A) quite high from the standard prescribed by WHO (50ng/liter). As, We found the amount of Napthalene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

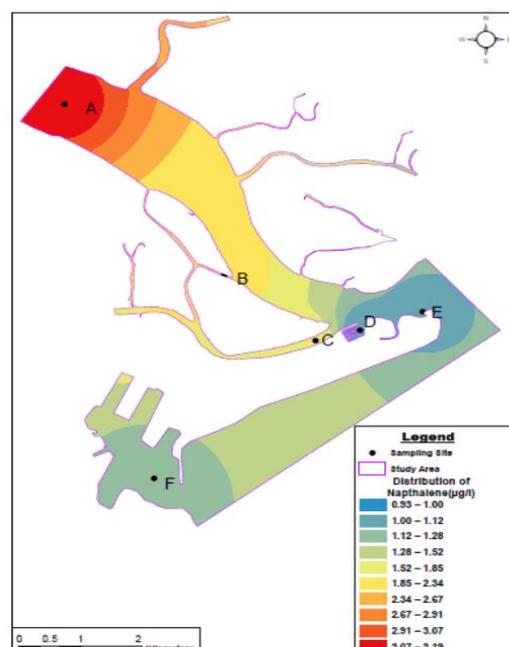


Fig.-4: Distribution of Napthalene

2. 2 bromo naphthalene

It is found that naphthalene varies from 1.0 ppb (site D) to 3.5 ppb (at site A) quite high from the standard prescribed by WHO (50ng/liter). As, We found the amount of 2 bromo Naphthalene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

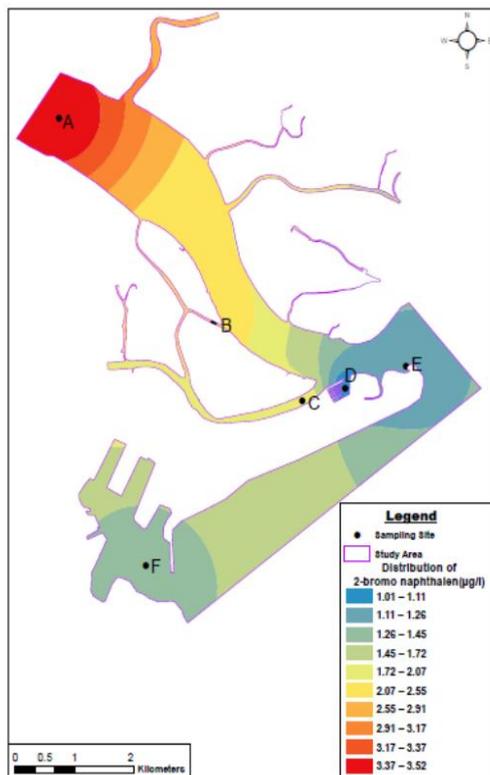


Fig.-5: Distribution of 2-Bromo naphthalene

3. Ace naphthylene

Acenaphthylene is a polycyclic aromatic hydrocarbon. The molecule resembles naphthalene with positions 1 and 8 connected by a C₂H₂ unit. It is a yellow solid. Ace naphthalene is used to make products for electronic engineering and plastics. It is a colorless crystalline solid. It is found that acenaphthylene varies from 1.1 ppb (site D) to 3.9 ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre).As, We found the amount of Ace naphthylene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

4. Acenaphthene

It is a polycyclic aromatic hydrocarbon consisting of naphthalene with an ethylene bridge connecting position 1 and 8. It is a colorless solid. Coal tar consists of about 0.3% of this compound. It was prepared the first time from coal tar by Marceline Berthelot. It is use large scale of prepare

naphthalene dicarboxylic anhydride, which is precursor to dyes and optical brighteners.

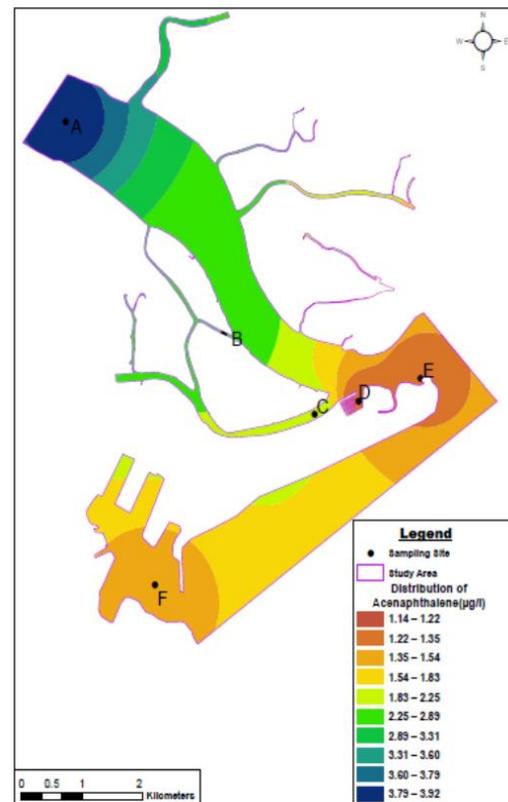


Fig.-6: Distribution of Acenaphthylene

It is found that acenaphthene varies from 1.0ppb (at site D) to 3.6 ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As, we found the amount of Acenaphthene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

5. Phenanthrene

Phenanthrene is a polycyclic aromatic hydrocarbon composed of three fused benzene rings. The name phenanthrene is a composite of phenyl and anthracene. In its pure form, it is found in cigarette smoke and is a known irritant, photosensitizing skin to light. Phenanthrene appears as a white powder having blue fluorescence. It is found in small amounts among a few coal burning sites. Ravatite represents a small group of organic minerals. It is found that phenanthrene varies from 1.1ppb (at site D) to 3.8 ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As, We found the amount of Phenanthrene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

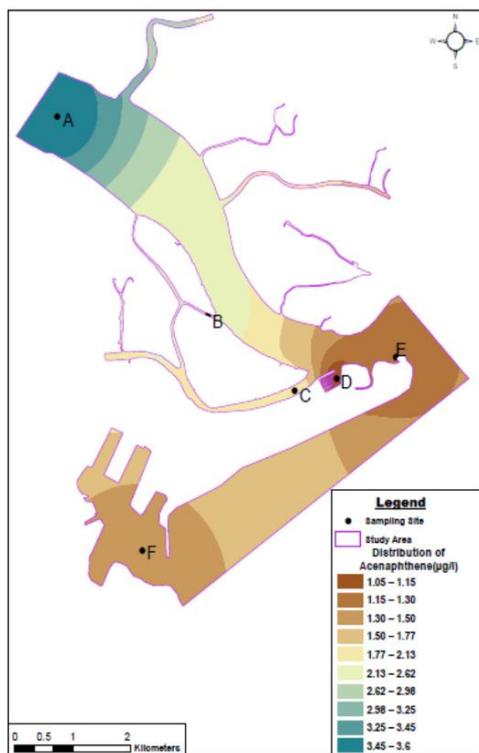


Fig-7: Distribution of Acenaphthene

6. Fluorine

Fluorine is a chemical element with the symbol F and atomic number 9. It is the lightest halogen and exists as a highly toxic pale yellow diatomic gas at standard conditions.

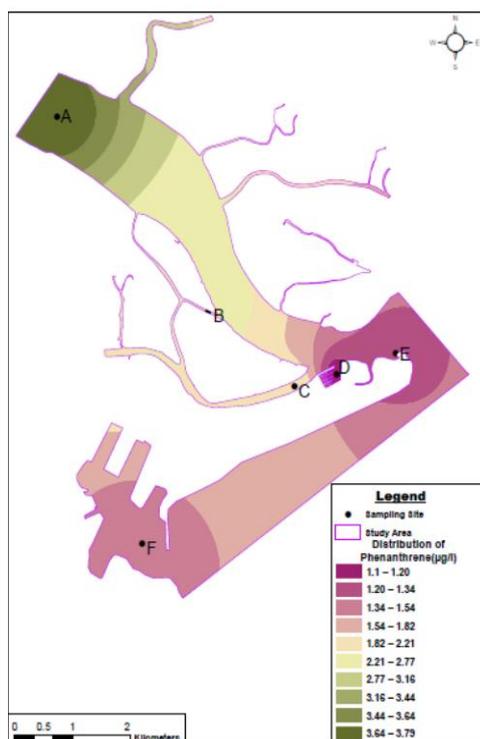


Fig-8: Distribution of Phenanthrene

Fluorocarbon gases are generally greenhouse gases with global warming potentials 100 to 20,000 times that of carbon dioxide. Fluorine has no known metabolic role in mammals; a few plants and sea sponges synthesize organofluorine poisons that help deter predation. Organofluorines exhibit biopersistence due to the strength of the carbon-fluorine bond. It is found that fluorine varies from 1.1ppb (at site D) to 3.7ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As we found the amount of Fluorine is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

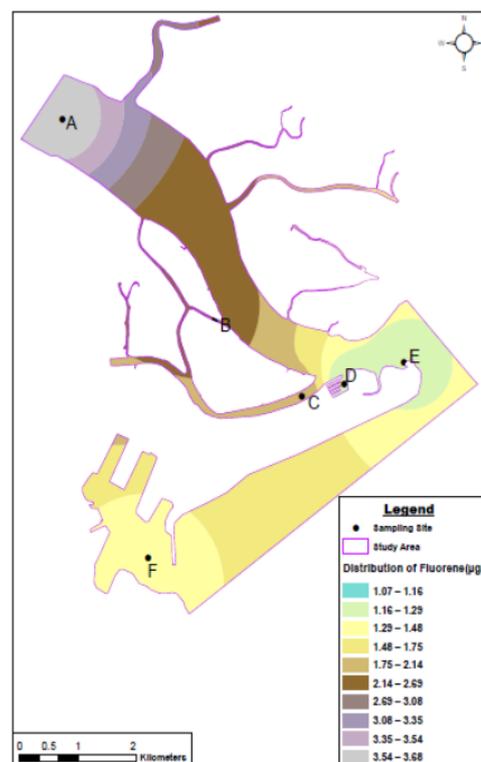


Fig-9: Distribution of Fluorene

7. Anthracene

Anthracene is a solid polycyclic aromatic hydrocarbon (PAH) of formula C₁₄H₁₀, consisting of three fused benzene rings. It is a component of coal tar. Anthracene is used in the production of red dye alizarin and other dyes. Anthracene is colorless but exhibits a blue (400-500 nm peak) fluorescence under ultraviolet radiation. It is found that anthracene varies from 1.2ppb (at site D) to 4.1ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As we found the amount of Anthracene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

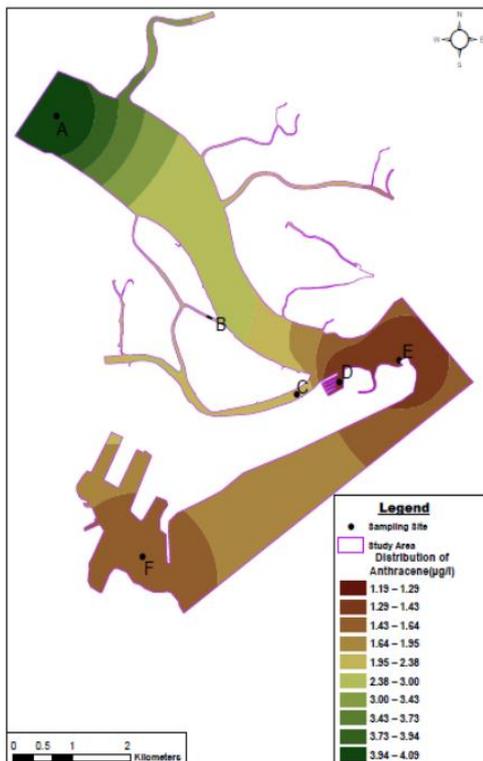


Fig-10: Distribution of Anthracene

8. Fluoranthene

It is a polycyclic aromatic hydrocarbon. The molecule can be viewed as the fusion of naphthalene and benzene unit connected by a five membered ring.

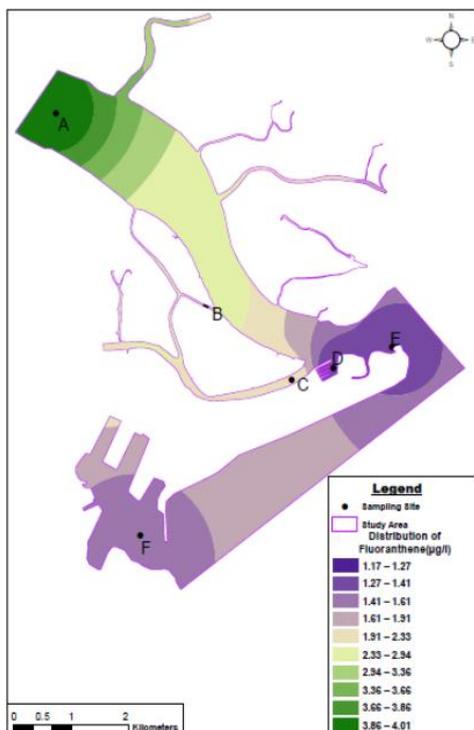


Fig-11: Distribution of Fluoranthene

Although samples are often pale yellow, the compound is colorless. It is soluble in nonpolar organic solvents. It is a member of the class of PAHs known as non alternant PAHs because it has rings other than those with six carbon atoms. It is a structural isomer of the alternant PAH pyrene. It is not as thermodynamically stable as pyrene. Its name is derived from its fluorescence under UV light. It is found that Fluoranthene varies from 1.2ppb (at site D) to 4.0ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As, We found the amount of Fluoranthene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

9. Pyrenees

The metallic ores of the Pyrenees are not in general of much importance now, through there were iron mines at several locations in Andorra, as well as at vicadessos in ariege, and the foot of canigou in Pyrenees -Orientales long ago. Coal deposits capable of being profitably worked are situated chiefly on the Spanish slopes, but the French side has beds of lignite. It is found that pyrenees varies from 1.2ppb (at site D) to 4.0ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As, We found the amount of Pyrenees is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

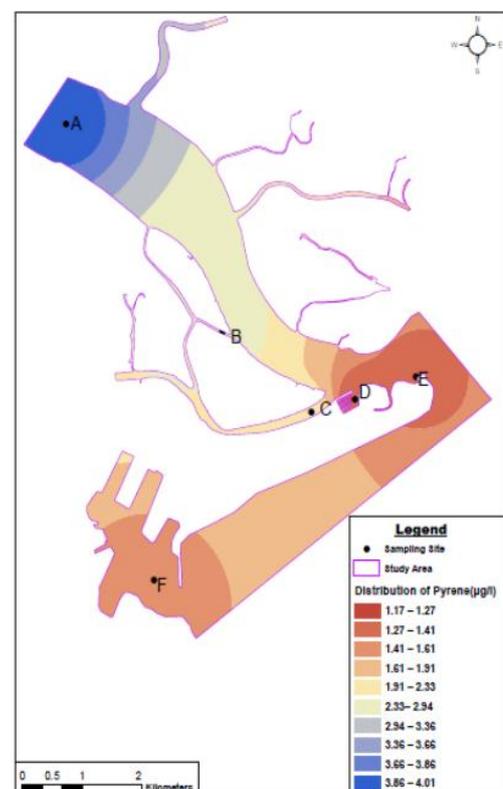


Fig-12: Distribution of Pyrene

10. Benzo(a)anthracene

Benzo(a)anthracene is a polycyclic aromatic hydrocarbon with the chemical formula C₁₈H₁₂. Benzo(a)anthracene is a carcinogenic constituent of tobacco smoke. It is found that benzo(a)anthracene varies from 1.2ppb (at site **D**) to 4.3ppb (at site **A**) quite high from the standard prescribed by WHO was (50ng/litre). As, we found the amount of Benzo(a)anthracene is maximum at site **A** and minimum at site **D**, we may get source at site **A** and also dilution at site **D** (As estuary point).

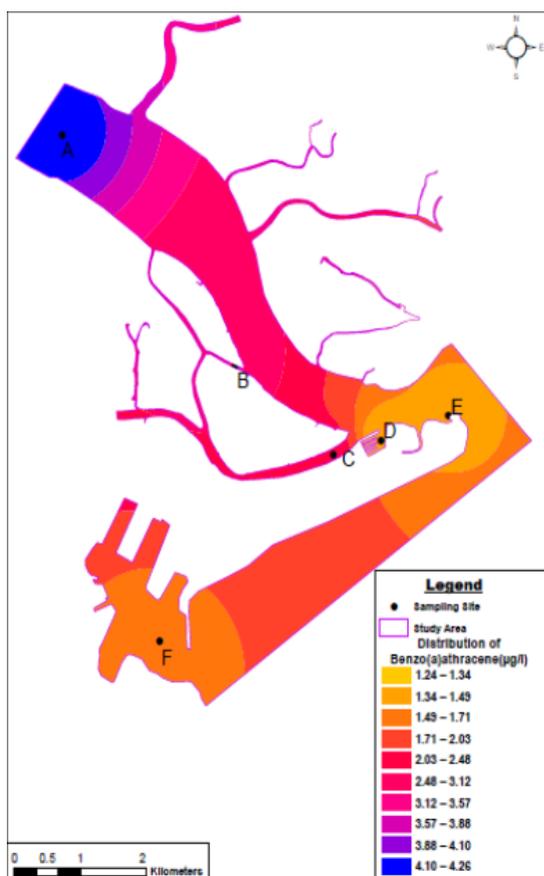


Fig.-13: Distribution of Benzo(a)anthracene

11. Chrysene

The name "chrysene" originates from Greek (chryso), meaning "gold" and is due to the golden-yellow color of the crystals of the hydrocarbon, through thought to be the proper color of the compound at the time of its isolation and characterization. Derivatives of chrysene include tetrahydrochrysene and 2,8-dihydroxyhexahydrochrysene, which are estrogenic compounds. The experimental cancer drug crisnatol is a derivative of chrysene. It is found that chrysene varies from 1.1ppb (at site **D**) to 3.8 (at site **A**) quite high from the standard prescribed by WHO was (50ng/liter). As, we found the amount of Chrysene is maximum at site **A** and minimum at site **D**, we may get source at site **A** and also dilution at site **D** (As estuary point).

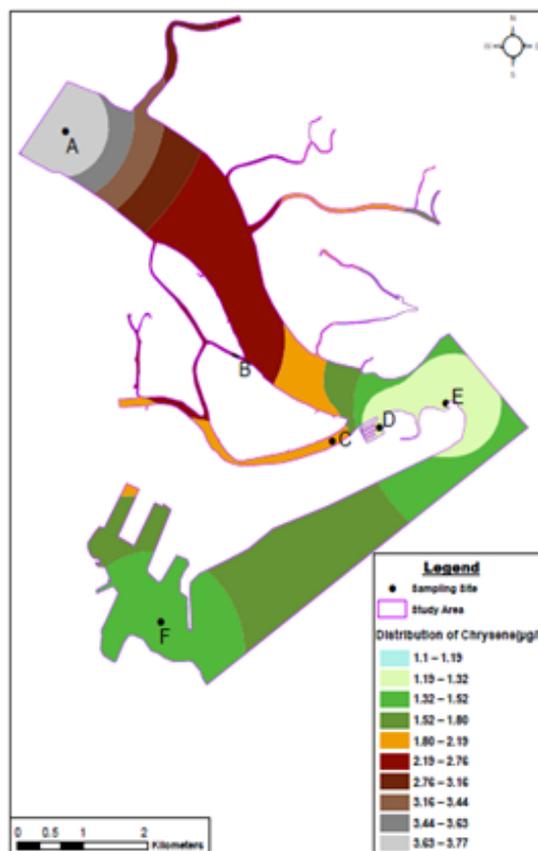


Fig.-14: Distribution of Chrysene

12. Benzo(b)fluoranthene

It is a colorless, needle-shaped solid. It is used as a research chemical and is present in coal, and coke oven emissions, petroleum products. Benzo(b)fluoranthene is on the hazardous substance list because it is regulated by OSHA and cited by ACGIH, NIOSH, NTP and EPA. Benzo(b)fluoranthene is an ortho- and peri fused polycyclic arene that consists of a benzene ring fused with aacephenanthrylene ring. It has a role as a mutagen. It is found that Benzo(b)fluoranthene varies from 1.2ppb (at site **D**) to 4.2ppb (at site **A**) quite high from the standard prescribed by WHO was (50ng/litre). As, we found the amount of Benzo(b)fluoranthene is maximum at site **A** and minimum at site **D**, we may get source at site **A** and also dilution at site **D** (As estuary point).

13. Benzo(a)Pyrene

It is a polycyclic aromatic hydrocarbon and the result of incomplete combustion of organic matter at temperatures between 300°C and 600°C. The ubiquitous compound can be found in coal tar, tobacco smoke and many foods, especially grilled mates. The substance with the formula C₂₀H₁₂ is one of the, benzopyrenes, formed by a benzene ring fused to pyrene. Its diol epoxide metabolites react and bind to DNA, resulting in mutations and eventually cancer.

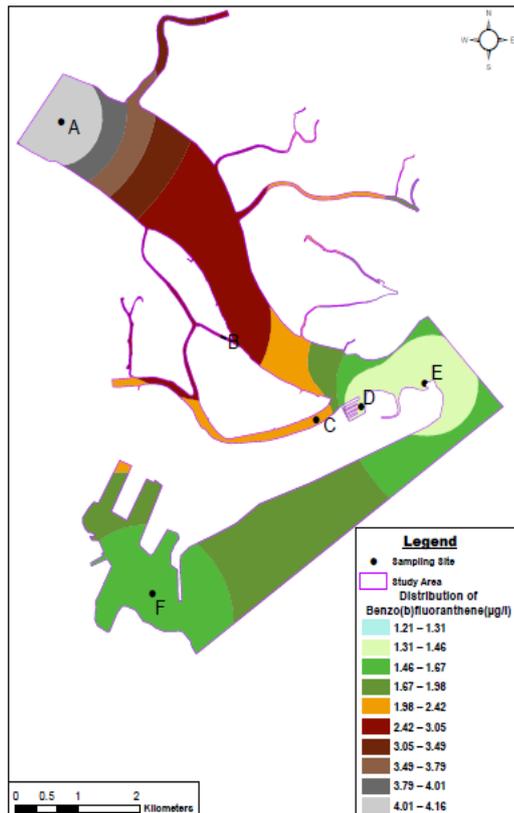


Fig.-15: Distribution of Benzo(b)fluoranthene

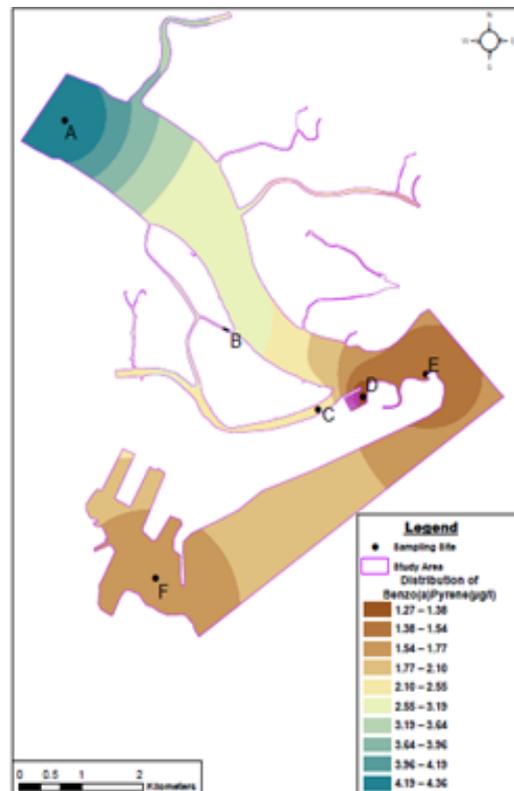


Fig.-16: Distribution of Benzo(a)pyrene

It is found that Benzo(a)pyrene varies from 1.3ppb (at site D) to 4.4 (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As, We found the amount of Benzo(a)pyrene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

14. Indeno(1,2,3-cd)pyrene

It is found that Dibenz(a,h)anthrance varies from 1.8ppb (at site D) to 6.2ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As, We found the amount of Indeno(1,2,3-cd)pyrene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

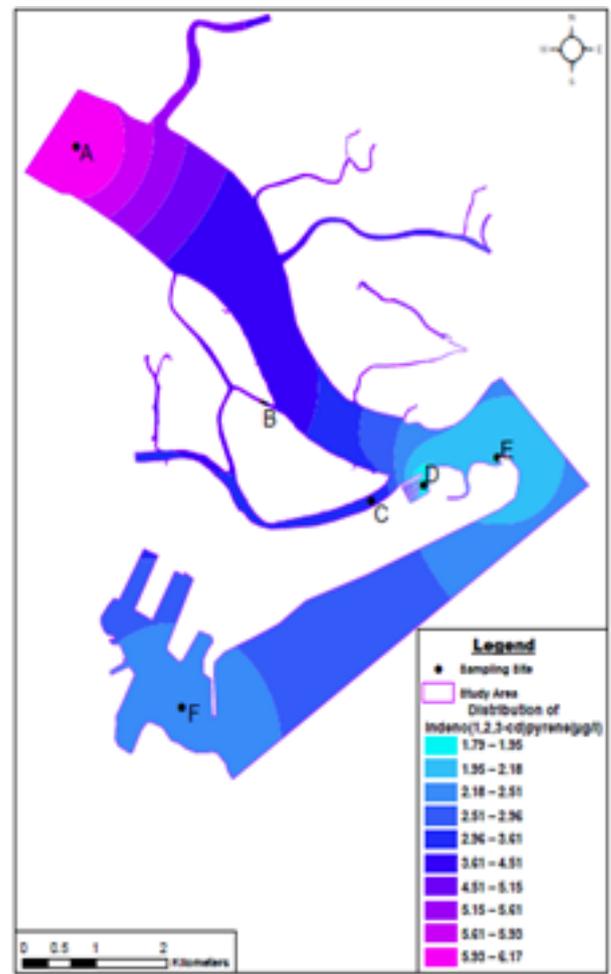


Fig.- 17: Distribution of Indeno(1,2,3-cd)pyrene

15. Benzo(g,h,i)Perylene

Pure benzo (g,h,i) perylene is usually found as pale yellow green crystal plates . It does not dissolve in water, but will dissolve readily in organic (carbon-containing) solvents. Benzo (g,h,i) perylene is one of a group of compounds known as the polycyclic aromatic compounds(PAH). It is used for

only relatively small amounts of benzo(g,h,i) pyrene are intentionally manufactured. It is extracted from coal tar to be used in dyes. It is found that Benzo(g,h,i)perylene varies from 1.2ppb (at site D) to 4.3ppb(at site A) .quite high from the standard prescribed by WHO was (50ng/liter). As, We found the amount of Benzo(g,h,i)perylene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

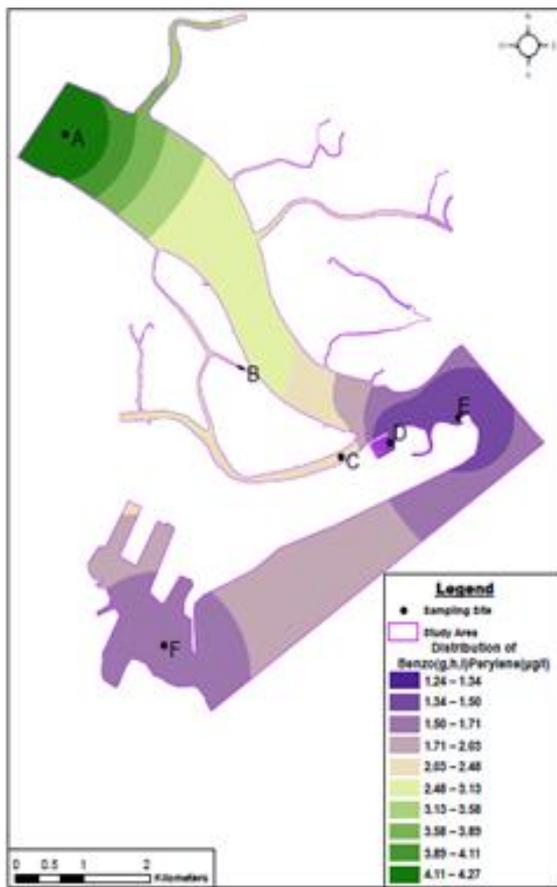


Fig.- 18: Distribution of Benzo(g,h,i)Perylene

16. Dibenz(a,h)Anthracene

Dibenz(a,h)Anthracene is an organic compound with the chemical with the chemical formula C₂₂H₁₄. It is a polycyclic aromatic hydrocarbon made of five fused benzene rings. It is fused five ringed, cyclopenta, PAHs compound which is common as a pollutant of smoke and oils. It is white to light yellow crystalline solid. It is stable and highly genotoxic in bacterial and mammalian cell systems, as it intercalates into DNA and causes mutations. It is found that Dibenz(a,h)anthracene varies from 1.8ppb (at site D) to 6.2ppb (at site A) quite high from the standard prescribed by WHO was (50ng/litre). As, We found the amount of Dibenz(a,h)anthracene is maximum at site A and minimum at site D, we may get source at site A and also dilution at site D (As estuary point).

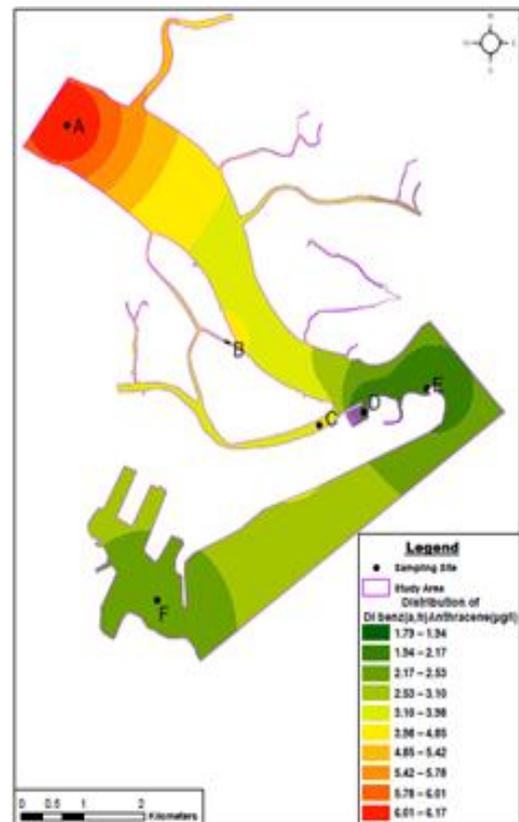


Fig.-19: Distribution of Di benz(a,h)Anthracene

Table-2: PAHs concentration presents in Mahanadi estuary

PAHs						
SAMPLING SITES	A	B	C	D	E	F
Napthalene(in ppb)	3.2	2.1	1.8	0.9	1.0	1.1
Acenapthalene(in ppb)	3.9	2.8	2.1	1.1	1.2	1.4
2-bromo naphthalene(in ppb)	3.5	2.3	1.9	1.0	1.1	1.3
Acenapthene(in ppb)	3.6	2.4	2.0	1.0	1.1	1.3
Fluorene(in ppb)	3.7	2.4	2.0	1.1	1.2	1.3
Phenanthrene(in ppb)	3.8	2.5	2.1	1.1	1.2	1.4
Anthracene(in ppb)	4.1	2.7	2.2	1.2	1.3	1.4
Fluoranthene(in ppb)	4.0	2.7	2.2	1.2	1.3	1.4
Pyrene(in ppb)	4.0	2.7	2.2	1.2	1.3	1.4
Benzo(a)athracene(in ppb)	4.3	2.8	2.3	1.2	1.4	1.5
Chrysene(in ppb)	3.8	2.5	2.1	1.1	1.2	1.3
Benzo(b)fluranthene(in ppb)	4.2	2.7	2.3	1.2	1.3	1.5
Benzo(a)pyrene(in ppb)	4.4	2.9	2.4	1.3	1.4	1.5
Indeno(1,2,3-cd)(in ppb)	6.2	4.1	3.4	1.8	2.0	2.2
Dibenz(a,h)anthracene(in ppb)	6.2	4.1	3.4	1.8	2.0	2.2
Benzo(g,h,i)perylene(in ppb)	4.3	2.8	2.3	1.2	1.4	1.5

4. CONCLUSIONS

This study provides important information on PAH concentrations in surface water of Mahanadi River, Estuary and sea. The Mahanadi estuary is engulfed with an upcoming industrial economic zone, having different industries including refinery and steel, making this area polluted in turn the ecosystem with respect to oil and refineries. This is particularly true about Mahanadi coast which is located close to the IOCL. This study, however, showed that PAHs concentrations exceeded the maximum admissible concentrations of PAHs ($50 \mu\text{g L}^{-1}$) according to the water standard and may cause toxicity to certain exposed organisms.

ACKNOWLEDGEMENT

The authors would like to thank the experts who were involved in the validation survey for this research project Mr. Anupam Behera, Nodal officer, iczmp, ospcb, Dr. S.S Pati, Env. Scientist, iczmp, ospcb, bbsr, Dr (Mrs.) Sangeeta Mishra, Asst. Env. Scientist, iczmp, ospcb, and Mrs. Sumitra Nayak, Asst. Env. Scientist, iczmp, ospcb, without their passionate participation and input, the validation survey could not have been successfully conducted.

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