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# Fluoranthene pollution and its toxic manifestations in aquatic invertebrates

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**Abstract**
Fluoranthene, a tetracyclic aromatic hydrocarbon is widespread in aquatic environment. It is even reported as one of the concerned compound amongst the list of '16 priority pollutant' by USEPA due to its abundance and toxic potentials. The all-round development of human civilization directly associated with uncontrolled rise of pollutants in all the three compartments of environment i.e. air, water and soil in spite of different adaptive and controlled measures adopted by different governmental and non-governmental organizations. The lipophilic property of fluoranthene facilitates the easy absorption into the fatty layers of aquatic biota and thereby causing different arrays of toxic manifestations from cellular to sub cellular levels. Aquatic invertebrates are key balancers of the aquatic food chains and are sensitive to aquatic pollutants that make excellent indicators of water quality and ecosystem health. Fluoranthene is reported to be capable of causing different toxicities in aquatic invertebrates. In view of the context, the recent article focuses on the current scientific findings regarding fluoranthene toxicity in aquatic invertebrates.

**Keywords:** fluoranthene, invertebrates, polycyclic aromatic hydrocarbons, pollution, toxicity

## Introduction

The all-round developments of human civilization directly associated with uncontrolled rise of pollutants in all the major compartments of environment over the past years and have been imposing interminable pressure upon ecosystems. Humans, for their daily survival benefits have been readily or accidentally adding on different anthropogenic pollutants in the environment. India being a developing country has been facing the extreme repercussion and it stands at the top five amongst the polluted countries of the world [19]. The incomplete combustion as well as pyrolysis of all organic substances such as coal, petroleum, natural gases, municipal waste have lead the production of organic pollutants which are collectively grouped into polycyclic aromatic hydrocarbons, PAHs [7]. USEPA has been published a list of '20 priority pollutants' based on the toxic intensities and abundances of PAHs including fluoranthene. Fluoranthene is one of the abundantly found PAHs in the aquatic environment. Its concentration in drinking water was reported as highest amongst the other PAHs [36]. The concentrations of fluoranthene were ranges from 1.4 µg/L [16] to 45 µg/L [14] in aquatic systems. The lipophilic property of fluoranthene facilitates the easy absorption into the fatty layers of aquatic biota and thereby causing different arrays of toxic manifestations from cellular to sub cellular levels [1]. Aquatic fauna are mostly vulnerable towards the fluoranthene present in their environment and amongst them invertebrates are the key balancers of the aquatic food chains as well as excellent indicators of water quality and ecosystem health. In view of the context, the recent article focuses on the current scientific findings regarding fluoranthene toxicity in aquatic invertebrates.

### Physical and chemical properties of fluoranthene

The physical appearance of fluoranthene is colorless crystalline solid [28] with its chemical formula and molecular weight as $C_{16}H_{10}$ and 202.25 respectively [3, 14]. Likewise, the melting and boiling point of fluoranthene is 110ºC and 384ºC respectively [3, 17]. The vapor pressure of fluoranthene is $1.91x10^{-3}$ mm Hg at 25°C and a log octanol/water coefficient of 5.2 [28]. It is sparingly soluble in water [21] and highly lipophilic [15] in nature with its solubility concentration as 265 µg/L (https://en.wikipedia.org/wiki/Fluoranthene). It also possesses chemically and biologically reactive "bay" and "K"-region epoxides mostly considered for suspected carcinogenic properties [12].

### Fluoranthene toxicity on aquatic invertebrates

Aquatic invertebrates are key balancers of the aquatic food chains that are inhabitants of both marine and freshwater ecosystems, and provide ample ecosystem services [11]. They are sensitive to aquatic pollutants and excellent indicators of water quality and ecosystem health [22, 26]. Fluoranthene is reported to be capable of causing different toxicities in aquatic invertebrates.

In a study performed in the year 1997, the exposure of fluoranthene with and without UV irradiations induced mortality in seven marine benthic crustaceans namely *Rhepoxynius abronius, Eohaustorius estuarius, Leptocheirus, plumulosus, Grandidierella japonica*, and *Corophium insidiosum*. However, the affect was significantly enhanced upon UV irradiations upto tenfold as that of the affect without UV irradiation [8].

Similar reports were reported in case of *Daphnia magna* upon its exposure [35]. Although, the survivorship of the same were increased when they were transferred from the fluoranthene contaminated water to pure water. Its treatment also caused histopathological alterations in terms of the reduction of average digestive epithelium thickness in the visceral mass of oysters, *Crassostrea virginica*, which is suggested as the useful histological indicator of fluoranthene induced stress in aquatic animals [32]. In the year 1999, Spehar *et al*. [27] had also performed an array of assessments to study the toxicity of fluoranthene in a total of 21 diverse group both fresh water and salt water invertebrate species in photo induced conditions in the presence of both laboratory fluorescent and UV light. As in the result, the rate of mortality in most of the species did not achieved within the solubility range provided the exposure was devoid of any irradiation. However, in the presence of the UV light, almost all the individuals of each species showed their sensitivity towards the fluoranthene presence in the medium [27].

The photo induced toxicity as well as the tissue concentration of fluoranthene in larval form is higher than adult midges (*Chironomus tentans*) as reported by Bell *et al*. [4]. In comparison between the two sexes of adult midges, the tissues concentration was much higher in females which correspond to the higher mortality as compared to males [4]. The fluoranthene exposure for consecutive six days with photo induced condition in the coral *Porites divaricata* also caused significant mortality [9]. Fluoranthene was predominantly studied in the context of photo induction and their synergistic effects in many aquatic animals are well documented. To add on some more databases, Ahrens *et al*. [2] had studied the sensitivity of the juveniles of bivalve, *M. liliana*. The tested bivalves were observed to be extremely sensitive with the increased tissue fluoranthene concentration even in the presence of short UV exposure. Similarly, aquatic crustaceans *Hyalella azteca* was also showed prominent toxic manifestations when treated with fluoranthene in water and sediment along with the varying light spectra *viz.*, gold fluorescent light ($\lambda > 500$), cool white fluorescent light, and UV-enhanced fluorescent light. Crustaceans, in water medium mostly showed their toxicity under UV spectra which followed by fluorescent light then under the gold light. However, in sediments the data observed was contrasting as in either light exposure did not cause any significant toxicity in the animals [37].

Weinstein and his group had also found synergistic effects of fluoranthene with UV radiation [29, 33, 34] and other factors like salinity [33], hypoxic and normoxic conditions [30]. In the presence of UV light, the fluoranthene toxicity was reported to be accelerated in the freshwater mussel glochidia, *Utterbackia imbecillis* [31, 34] and in oligochaete, *Monopylephorus rubroniveus* [29, 33] and larvae of the grass shrimp *Palaemonetes pugio* [33]. Likewise, salinity was also reported to influence the bioaccumulation as well as photo induced toxicity of the fluoranthene in oligochaete, *Monopylephorus rubroniveus* [33]. Weinstein and Sanger [30] also had studied the effect of fluoranthene under normoxic and hypoxic condition in annelids and found to be species dependent and the oligochaete, *Monopylephorus rubroniveus* was found to be the most sensitive in either of the two conditions as compared to the polychaete, *Streblospio benedicti*. In case of deposit-feeding Polychaete *Capitella* sp., its exposure caused reduction in growth and body weight [24] with time dependent DNA damage in their erythrocytes [20]. Exposure 335µg/L of fluoranthene for 5 days in marine snail *Littorina littorea* caused reduced lysosomal stability, endocytosis with induced smooth endoplasmic reticulum (ER) and 7-ethoxycoumarin-o-deethylase (ECOD) activity in isolated live digestive cells. However, the removal of fluoranthene from the test medium had repaired these alterations within 8 days [18].

The exposure of fluoranthene also reported to induced mortality and reduced the rate of egg production, hatching as well as recruitment time of the calanoid copepod *Acartia tonsa* [6]. According to Bellas *et al*. [5], fluoranthene may pose severe risk for mussel and seaurchin as it caused severe mortality of European amphipods such as *Gammarus aequicauda*, *Gammarus locusta*, and *Corophium multisetosum* depicting its 48 h $LC_{50}$ were 49.99, 42.71 and 2.85 µg/L respectively [23]. Chung *et al*. [10] also performed a comparative study with three different environmental contaminant which included fluoranthene and two other pesticides namely carbaryl and diquat dibromide. Experiment was carried out in larval grass shrimp, *Palaemonetes pugio*. Amongst them, fluoranthene was reported to be highly toxic to the tested shrimp and the mixture of all the three contaminant exhibited additive results [10]. The nematode *Caenorhabditis elegans* was also reported to be sensitive to fluoranthene exposure and caused alteration in growth and reproduction that ultimately leads to the mortality of the organisms [25]. Fluoranthene also altered different oxidative status in the mussels (*Mytilus galloprovincialis*). In additions, it was also observed that nutritive status of the organism also act as an important factor for fluoranthene toxicity [13].

## Conclusion

Aquatic vertebrates are one of the vital components of aquatic food web and stabilize different ecosystems. They are regarded as the key balancers and have different ecological functions. They acts as sentinels of aquatic ecosystems and are regarded as excellent bioindicators of environmental pollutions. Other than these, the marine and freshwater invertebrate also plays a significant role in modulating aquatic structure and functions. From the above discussions it has been observed that the increasing fluoranthene pollution directly or indirectly hampers different biological functions in most of the studied aquatic invertebrates affecting minimal to severe toxic manifestations in a cellular and molecular levels. To check on the incidences and toxicological evaluations research fraternity should pay greater attention on detailed toxicity evaluations and their possible remediations.

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## References

1. Abdel-Shafy HI, Mansour MS. A review on polycyclic aromatic hydrocarbons: source, environmental impact, effect on human health and remediation. Egyptian journal of petroleum. 2016; 25(1):107-23.
2. Ahrens MJ, Nieuwenhuis R, Hickey CW. Sensitivity of juvenile *Macomona liliana* (Bivalvia) to UV-photoactivated fluoranthene toxicity. Environmental Toxicology: An International Journal. 2002; 17(6):567-77.

3. ATSDR. Toxicological Profile for Polycyclic Aromatic Hydrocarbons. Acenaphthene, Acenaphthylene, Anthracene, Benzo (a) anthracene, Benzo (a) pyrene, Benzo (b) fluoranthene, Benzo (g,i,h) perylene, Benzo (k) fluoranthene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluorene, Indeno (1,2,3-c,d) pyrene, Phenanthrene, Pyrene. Prepared by Clement International Corporation, under. 1990; 205:88-0608. ATSDR/TP-90-20.
4. Bell HE, Liber K, Call DJ, Ankley GT. Evaluation of bioaccumulation and photo-induced toxicity of fluoranthene in larval and adult life-stages of Chironomus tentans. Archives of environmental contamination and toxicology. 2004; 47(3):297-303.
5. Bellas J, Saco-Álvarez L, Nieto Ó, Beiras R. Ecotoxicological evaluation of polycyclic aromatic hydrocarbons using marine invertebrate embryo–larval bioassays. Marine Pollution Bulletin. 2008; 57(6-12):493-502.
6. Bellas J, Thor P. Effects of selected PAHs on reproduction and survival of the calanoid copepod *Acartia tonsa*. Ecotoxicology. 2007; 16(6):465-74.
7. Bhuyan K, Giri A. Polycyclic Aromatic Hydrocarbon Compounds as Emerging Water Pollutants: Toxicological Aspects of Phenanthrene on Aquatic Animals. In Effects of Emerging Chemical Contaminants on Water Resources and Environmental Health. 2020. 45-67. IGI Global.
8. Boese BL, Lamberson JO, Swartz RC, Ozretich RJ. Photoinduced toxicity of fluoranthene to seven marine benthic crustaceans. Archives of Environmental Contamination and Toxicology. 1997; 32(4):389-93.
9. Carmen Guzmá N, Martínez MD, Romero PR, Banaszak AT. Photoinduced toxicity of the polycyclic aromatic hydrocarbon, fluoranthene, on the coral, *Porites divaricata*. Journal of Environmental Science and Health, Part A. 2007; 42(10):1495-502.
10. Chung KW, Chandler AR, Key PB. Toxicity of carbaryl, diquat dibromide, and fluoranthene, individually and in mixture, to larval grass shrimp, *Palaemonetes pugio*. Journal of Environmental Science and Health Part B. 2008; 43(4):293-9.
11. Covich AP, Palmer MA, Crowl TA. The role of benthic invertebrate species in freshwater ecosystems: zoobenthic species influence energy flows and nutrient cycling. Bio Science. 1999; 49(2):119-27.
12. Fawell JK, Hunt S. The polycyclic aromatic hydrocarbons. In: Fawell, J. K., Hunt, S. (eds) Environmental toxicology: organic pollutants.1988. Ellis Horwood, West Sussex, 1988, 241-269.
13. González-Fernández C, Albentosa M, Campillo JA, Viñas L, Romero D, Franco A, *et al*. Effect of nutritive status on *Mytilus galloprovinciali*s pollution biomarkers: implications for large-scale monitoring programs. Aquatic Toxicology. 2015; 167:90-105.
14. IARC. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans. Vol. 32: Polynuclear aromatic compounds: Part 1. Chemical, environmental and experimental data. Lyons, France: World Health Organization. International Agency for Research on Cancer. 1983; 155-161:225-231.
15. IPCS. Selected Non heterocyclic Polycyclic Aromatic Hydrocarbons. Environmental Health Criteria. World Health Organization, Geneva, 1998.
16. Law RJ, Dawes VJ, Woodhead RJ, Matthiessen P. Polycyclic aromatic hydrocarbons (PAH) in seawater around England and Wales. Marine pollution bulletin. 1997; 34(5):306-22.
17. Lide DR, editor. CRC handbook of chemistry and physics. CRC Press, 2004.
18. Lowe DM, Moore MN, Readman JW. Pathological reactions and recovery of hepatopancreatic digestive cells from the marine snail *Littorina littorea* following exposure to a polycyclic aromatic hydrocarbon. Marine environmental Research. 2006; 61(5):457-70.
19. Malla C. Air Pollution in India (Comparing with USA and China). Indian Journal of Environmental Sciences. 2019; 23(2):79-84.
20. Palmqvist A, Selck H, Rasmussen LJ, Forbes VE. Biotransformation and genotoxicity of fluoranthene in the deposit-feeding polychaete *Capitella* sp. I. Environmental Toxicology and Chemistry: An International Journal. 2003; 22(12):2977-85.
21. Pearlman RS, Yalkowsky SH, Banerjee S. Water solubilities of polynuclear aromatic and heteroaromatic compounds. Journal of physical and chemical reference data. 1984; 13(2):555-62.
22. Reynoldson TB, Metcalfe-Smith JL. An overview of the assessment of aquatic ecosystem health using benthic invertebrates. Journal of aquatic ecosystem health. 1992; 1(4):295-308.
23. Sanz-Lázaro C, Marin A, Borredat M. Toxicity studies of polynuclear aromatic hydrocarbons (PAHs) on European amphipods. Toxicology mechanisms and methods. 2008; 18(4):323-7.
24. Selck H, Palmqvist A, Forbes VE. Uptake, depuration, and toxicity of dissolved and sediment-bound fluoranthene in the polychaete, *Capitella* sp. I. Environmental Toxicology and Chemistry: An International Journal. 2003; 22(10):2354-63.
25. Sese BT, Grant A, Reid BJ. Toxicity of polycyclic aromatic hydrocarbons to the nematode *Caenorhabditis elegans*. Journal of Toxicology and Environmental Health, Part A. 2009; 72(19):1168-80.
26. Slooff W. Benthic macroinvertebrates and water quality assessment: some toxicological considerations. Aquatic Toxicology. 1983; 4(1):73-82.
27. Spehar RL, Poucher S, Brooke LT, Hansen DJ, Champlin D, Cox DA, *et al*. Comparative toxicity of fluoranthene to freshwater and saltwater species under fluorescent and ultraviolet light. Archives of environmental contamination and toxicology. 1999; 37(4):496-502.
28. USEPA. Health Effects Assessment for Dimethylphenols. United States Environmental Protection Agency, 1987, EPA/600.8-88/031. Environmental Criteria Assessment Office, Cincinnati, OH.
29. Weinstein JE, Sanger DM, Holland AF. Bioaccumulation and toxicity of fluoranthene in the estuarine oligochaete *Monopylephorus rubroniveus*. Ecotoxicology and environmental safety. 2003; 55(3):278-86.
30. Weinstein JE, Sanger DM. Comparative tolerance of two estuarine annelids to fluoranthene under normoxic and

moderately hypoxic conditions. Marine environmental research. 2003; 56(5):637-48.

31. Weinstein JE. Characterization of the acute toxicity of photoactivated fluoranthene to glochidia of the freshwater mussel, *Utterbackia imbecillis*. Environmental Toxicology and Chemistry: An International Journal. 2001; 20(2):412-9.
32. Weinstein JE. Fluoranthene-induced histological alterations in oysters, *Crassostrea virginica*: seasonal field and laboratory studies. Marine environmental research. 1997; 43(3):201-18.
33. Weinstein JE. Influence of salinity on the bioaccumulation and photoinduced toxicity of fluoranthene to an estuarine shrimp and oligochaete. Environmental Toxicology and Chemistry: An International Journal. 2003; 22(12):2932-9.
34. Weinstein JE. Photoperiod effects on the UV-induced toxicity of fluoranthene to freshwater mussel glochidia: absence of repair during dark periods. Aquatic toxicology. 2002; 59(3-4):153-61.
35. Wernersson AS, Dave G. Effects of different protective agents on the phototoxicity of fluoranthene to Daphnia magna. Comparative Biochemistry and Physiology Part C: Pharmacology, Toxicology and Endocrinology. 1998; 120(3):373-81.
36. Wernersson AS, Dave G. Effects of different protective agents on the phototoxicity of fluoranthene to Daphnia magna. Comparative Biochemistry and Physiology Part C: Pharmacology, Toxicology and Endocrinology. 1998; 120(3):373-81.
37. WHO. Polynuclear aromatic hydrocarbons in Drinking-water: Background document for development of WHO Guidelines for Drinking-water Quality. 1998. World Health Organization, Geneva, (WHO/ SDE/ WSH/ 03.04/59).
38. Wilcoxen SE, Meier PG, Landrum PF. The toxicity of fluoranthene to *Hyalella azteca* in sediment and water-only exposures under varying light spectra. Ecotoxicology and environmental safety. 2003; 54(1):105-17.