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 [16]. 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 C16H10 and 202.25 respectively [3, 14]. Likewise, the melting and boiling point of fluoranthene is 110°C and 384°C 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, 20]. 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 (Chiromonus 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 (λ=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 searurchin as it caused severe mortality of European amphipods such as *Gammarus aequicauda*, *Gammarus locusta*, and *Corophium multisetosum* depicting its 48 h LC50 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**

3. ATSDR. Toxicological Profile for Polycyclic Aromatic Hydrocarbons. Acenaphthen, Acenaphthylene, Anthracene, Benzo (a) anthracene, Benzo (a) pyrene, Benzo (b) fluoranthene, Benzo (g,h,i) 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.


30. Weinstein JE, Sanger DM. Comparative tolerance of two estuarine annelids to fluoranthene under normoxic and


