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## The Toxicity Effects of Ash Emitted from Durah Power Plant on *Pleuroxus hamulatus* Birge, 1910 (Cladocera: Crustacea)

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### Abstract

Durah power plant (DPP) ash acute toxicity estimation was done by exposing Cladoceran *Pleuroxus hamulatus* Birge, 1910 to different ash concentrations. Thus, this study was regarded as pioneering by evaluating these effluents' harmful effects on the chosen laboratory food chain individuals. The LC<sub>50</sub> of ash on *P. hamulatus* were 0.04, 0.02 and 0.01 ppt during 24, 48 and 72 hr. respectively. On the other hand, our result showed that the increase in the ash concentrations leads to the maximum increase in mortality percentages value. Additionally, there were some clear behavioral changes seen in the animals, including slowness at first, followed by settling on the bottom of the beakers with stopped thorax, antennae appendages and a weak heartbeat. It was also observed that the survival was inhibited, and the mortality rate increased which may be due to the presence of toxic ash elements and the pH level change, both of which had a negative impact. The current study concluded that the acute toxicity exposure on *P. hamulatus* had harmful effects on all biological aspects of this aquatic food chain organisms.

**Keywords:** Toxicity; LC<sub>50</sub>; Cladocera, *Pleuroxus hamulatus*; Fly ash.

## التأثيرات السمية للرماد المنبعث من محطة كهرباء الدورة على ( Cladocera: *Pleuroxus hamulatus* Birge, 1910 (Crustacea)

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### الخلاصة

تم تقدير السمية الحادة للرماد المنبعث من محطة كهرباء الدورة عن طريق تعريض برغوث الماء *Pleuroxus hamulatus* لتراكيز رماد مختلفة. وبالتالي، تم اعتبار هذه الدراسة الأولى من نوعها من حيث تقييم التأثيرات السامة لهذه النفايات السائلة في افراد مختارين من السلسلة الغذائية مختبرياً. بلغت قيمة التركيز القاتل لنصف العدد 0.04 و 0.02 و 0.01 جزء بالالف بعد مرور 24 و 48 و 72 ساعة على التوالي من تعريض النوع لتراكيز الرماد المستخدمة. كما اظهرت نتائج الدراسة الحالية أن الزيادة في تراكيز الرماد تؤدي

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إلى أقصى زيادة في قيمة نسب الوفيات. كما تم تسجيل بعض التغيرات السلوكية للحيوان المدروس خلال فترة التعريض والمتمثلة بتباطؤ السباحة مع هبوط الكائن للقعر وتوقف اللواحق الصدرية وضعف نبض القلب. من خلال ماسبق أصبح من الواضح أن للرماد المستخدم التأثير السلبي على طول مدة الحياة وبالتالي زيادة النسب المئوية للهلاكات، وقد يعزى سبب ذلك إلى المكونات السامة التي يحتويها الرماد إضافة إلى قابلية الرماد في تغيير قيمة الأس الهيدروجيني pH للوسط وبالتالي حدوث التأثير المؤذي للحيوان المعرض.

## 1. Introduction

The availability of freshwater is one of the biggest issues facing the world and about one-third of the world's need for drinking water comes from surface sources such as rivers, dams, lakes and canals [1].

Surface water is one of the most affected ecosystems on earth and changes to it have resulted in significant ecological degradation, including a decline in water quality and availability [2].

Over the next half-century, Iraqi thermal power plants may pose a bigger risk to biodiversity and abundance of Iraq's waterbodies than all other pollutants anthropogenic. Among the toxic covered in the proposed rule for existing Iraq's waterbodies is ash which when dumped pollutes the environment through dusting and has a severe influence on water supplies due to the discharge of toxic substances into surface and ground water. Also, ash is now more widely acknowledged as a source of diffuse polluted in freshwater ecosystems and has detrimental a negative effect on the streams and lakes biota, including fish's [3] [4] [5] [6] [7], amphibians [8], macro and micro invertebrates [9] [5] [10] and algae [11] [5] [12]. The idea is that, since the biota as it provides the data on the actual biological impacts, it is the best indicator of ecological changes [13] [14]. So, this study aimed to explore the impact of fly ash from Durah power plant effluents (before discharged without any treatment to Tigris River) on the survival and their mortality percentages of *Pleuroxus hamulatus* Birge, 1910, which is considered as the attractive tool for researchers in the toxicity scope.

## 2. Material and Methods

### 2.1 Samples Collection

The pure culture of *P. hamulatus* was sorted from Masjid Um-Alqura canal west of Baghdad. *Pleuroxus hamulatus* was recognized according to the long rostrum, round inferoposteal angle without teeth, reticulated valves and almost marked by very fine striae with longitudinally run nearly [15] [16].

The dissolved oxygen concentration of the culture was about 1-14 mg/L which was carried out by using the oxygen meter, type Oxi 315 and made in Germany WIW. The water aquaria temperature was  $20 \pm 4^\circ\text{C}$  while the pH was between 7.2 and 8.3, as well as few drops of algae solution were used as a culture nutrition [17] [18]. In addition, the culture of *P. hamulatus* was photoperiod exposed 12/12 hour (light/dark) [19].

### 2.2 Organisms Culture and Ash Exposure

One hundred adult *P. hamulatus* females were isolated in beakers with 120ml tap water until they hatched and then the healthy juveniles were taken from the first brood [20]. Ten groups of ash concentrations were used 0.01,0.02,0.03,0.04,0.05,0.06,0.07,0.08,0.09 and 0.1ppt in addition to the control group. All the concentrations were prepared by weighing 100mg of solid ash which was dissolved in 1000ml of distilled water. Through the use of

the dilution equation we prepare the other minimum concentrations (as shown by the equation below) [21]:

$$C1 \times V1 = C2 \times V2$$

Six animals per these ten groups were divided, so that about 60 individuals could be taken with 24h. age to start the acute toxicity, as well as in the control group. All the juveniles were examined for deaths at the same time each day to determine the mortality percentages.

According to USEPA [22] the experiment tests were conducted under the controlled conditions such as pH  $7 \pm 0.2$ , while the water temperature  $20 \pm 2^\circ\text{C}$  and the photoperiod 12h light /12h dark.

During the experimental period no food or air was added without any replacement to the test solution [23]. The median lethal concentration was examined depending on the mortality percentages during 24, 48 and 72 hours and according to the equation below:

$$\text{Mortality percentage\%} = \frac{\text{Number of mortal animals in each conc.}}{\text{Total number of animals group}} \times 100$$

### 2.3 Analysis of Toxicity and $LC_{50}$

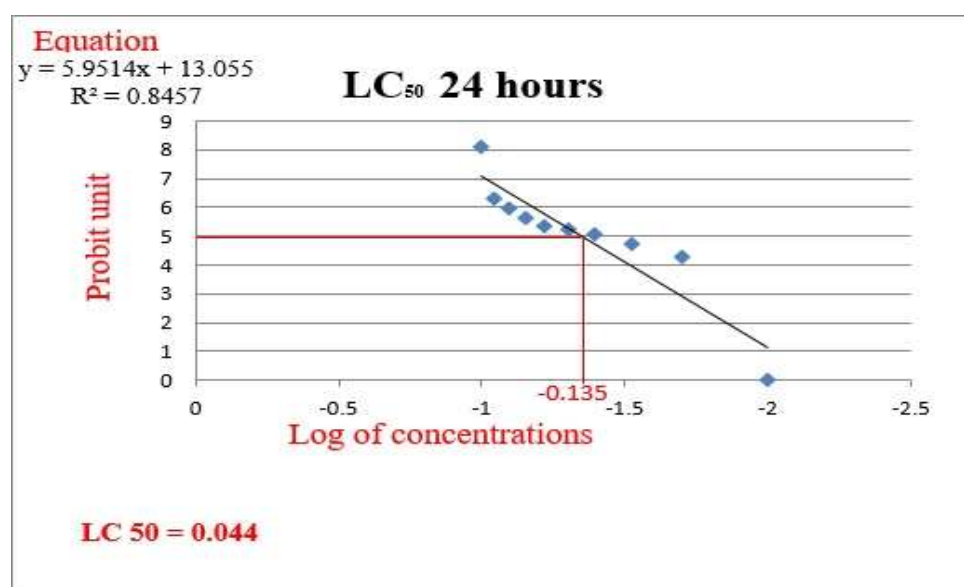
The  $LC_{50}$  was calculated according to the percentage of mortalities between the tested organisms at two or more concentrations. One of the concentrations should have less than 50% of deaths, while the other should have more than 50% of deaths [24].

### 2.4 Analysis of Data

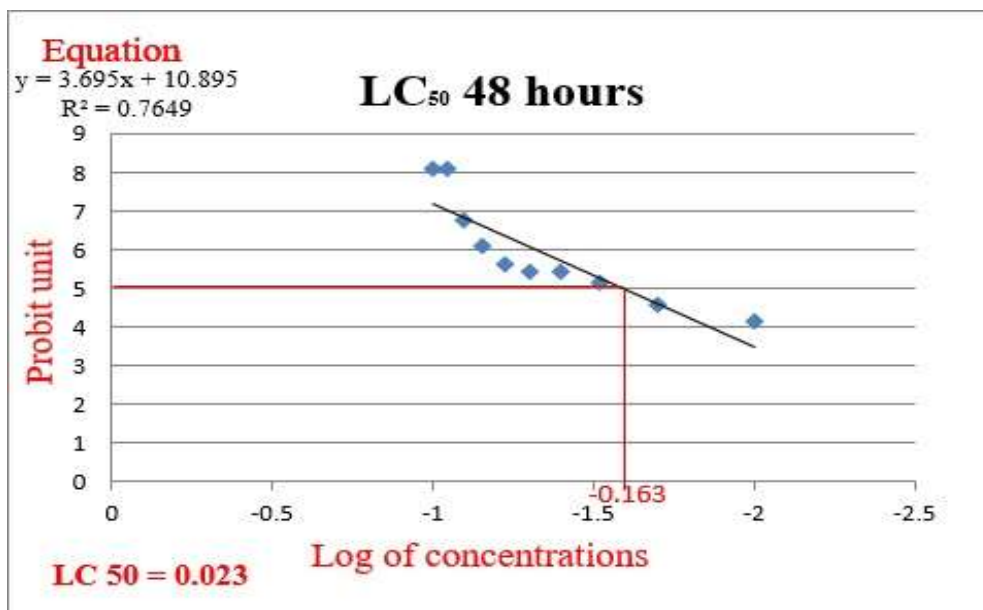
The data was analyzed by using Goldstein method [25] which includes conversion of the mortality percentages to their probit units as well as conversion of the ash concentrations to its opposite log, and then using the linear regression equation curve, the plotting between number 5 of the probit units and Log concentration represents the  $LC_{50}$  value after converting it to anti- log.

## 3. Result and Discussions

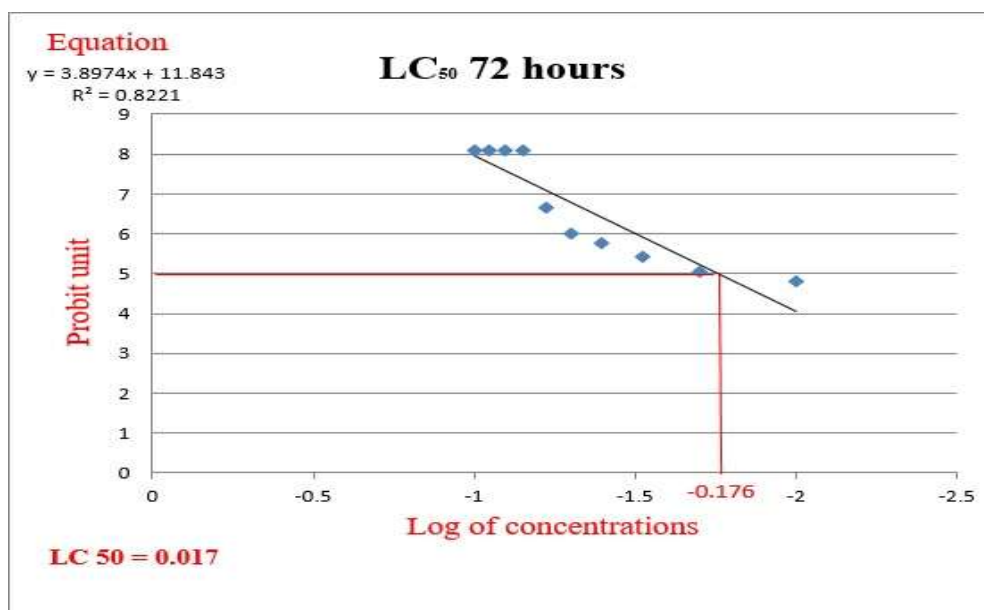
The acute toxicity test was conducted to evaluate the impact of ash solution towards the death of 50% of *P. hamulatus*. The results determined for the median lethal concentration ( $LC_{50}$ ) of *P. hamulatus* in 24, 48 and 72hr. were 0.044 ,0.0235 and 0.0175 ppt, respectively (Figures1, 2 and 3).



**Figure 1:** Median lethal concentration of *P. hamulatus* after 24 hrs. of exposure.

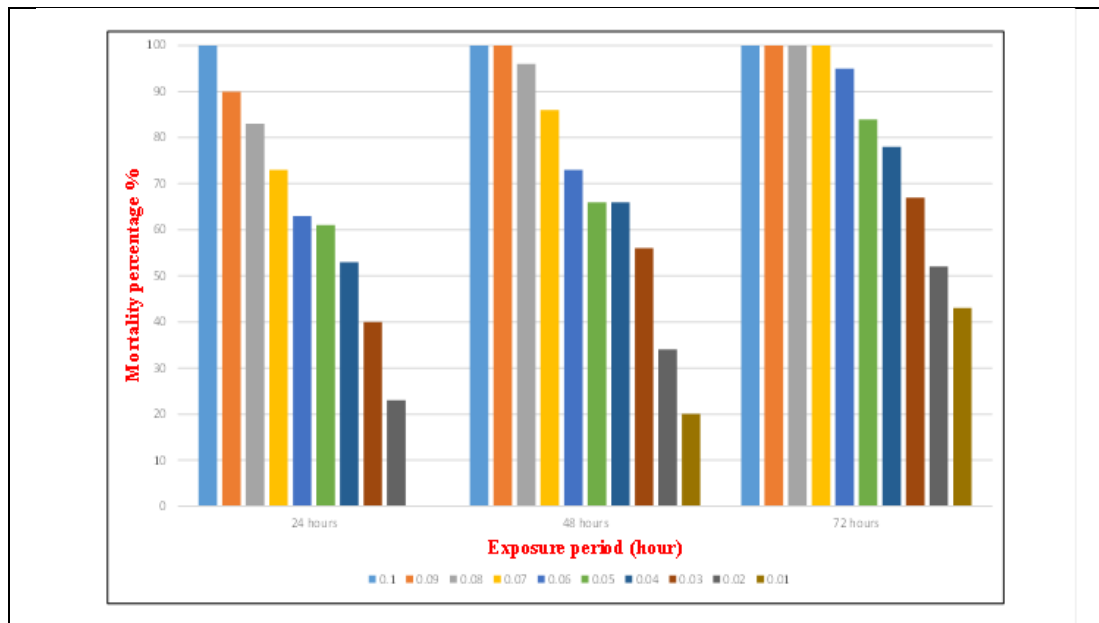


**Figure 2:** Median lethal concentration of *P. hamulatus* after 48 hrs. of exposure.



**Figure 3:** Median lethal concentration of *P. hamulatus* after 72 hrs. of exposure.

Figure (4) shows a significant decline in the survival of *P. hamulatus* during the exposure period to ash concentration. Complete mortality was recorded at higher concentration in comparison with the control group. It was noted that 100% mortality percentage (LC<sub>100</sub>) happened when exposed to 0.1 ppt concentration during 24 hr. of exposing. In addition, when exposed to 0.01 ppt, the minimum mortality percentages were 0% (LC<sub>0</sub>) for the same exposure period. This percentage increased after 48 and 72 hrs to 20% and 43% respectively at the same concentration. On the other hand, the survival between the control groups was 100%.



**Figure 4:** Mortality percentage (%) of *P. hamulatus* during the exposure period.

The mortality percentages increased clearly when ash concentrations increased and prolonged the exposure period even in the lower concentrations. Our results also agree with some other studies such as Ahmed and Khan's study [26] where they found that when the mortality percentage was increased significantly with the experiment period prolonged to seven days of exposed Nematode: *Meloidogyne incognita* to multiple concentrations of fly ash. A higher sensitivity effectiveness appeared towards the toxic substances in ash for all the organisms and this was proved from the toxicity in the current results. Whereas the  $LC_{50}$  values in the current study were lower than those recorded by Othman *et al.* [27] after 96 hours of *Melanoides tuberculata* being exposed to cobalt concentrations, the  $LC_{50}$  value was 0.14 mg/L.

Our finding showed a negative effectiveness of *P. hamulatus* towards ash concentrations according to the lower  $LC_{50}$  value which was evaluated in the current study and which could be due to the toxicity effect that was higher than those recorded by the other toxicity tests or perhaps due to the ash's heavy metal content which is known to have caused bioaccumulation during the dietary exposure, and the final possibility was agreeing with the study by Baun *et al.* [28] where they demonstrated fullerene's and its co-toxicity exposure's with three pollutants phenanthrene, methyl parathion and pentachlorophenol on *D. magna*. Their results improved high adsorption capacity of phenanthrene (85%) and pentachlorophenol (10%). This was also proved by Qviberg [29] who found that the toxic metals in ash concentrations caused negative effects when exposed to *Daphnia magna* which could be associated with anions metals with lipophilic compounds that can have a harmful impact during the exposure period. The same thing was also observed by Seke *et al.* [30] where they studied the toxicity effects of Buckminsterfullerene (C60) with color methane. Buckminsterfullerene (C60) induced synergistic mito-toxicity in the midgut and epithelial cells of *Daphnia magna*, especially that all the crustaceans are filter-feeders, and therefore, all ingested particles in water may harm their digestive tracts resulting in death.

It was noted that the survival rates were inhibited by ash concentrations. This could be attributed to ash particles that the presence of toxic components with sharp edges structures caused damage in the midgut epithelium, mitochondrial swelling, necrosis, cristolysis and

death [5]. On the same context, the bioaccumulation and the uptake of the metals in the crustaceans may be connected to the gut microbes' ability to absorb these metal pollutants. These results showed a clear sensitivity of *P. hamulatus* towards ash concentrations [31].

The high toxicity effects of this study were clear, even though the LC<sub>50</sub> values were lower than another toxicity reported such as by Sales [32] who observed that the LC<sub>50</sub> values for arsenic (ASIII) exposure to *Ceriodaphnia silvester* and *Daphnia similis* were 0.44 and 0.45 mg/L respectively. Nevertheless, the current study was close to the results of Al-Naymi et al. [10] who recorded that the LC<sub>50</sub> values on *S. vetulus* using ash from the Durah power plant were 0.14, 0.11 and 0.1 ppt during periods of 24, 48, and 72 hours respectively.

The higher mortality rate observed could be the cause of the absence of the toxicity curve after 96 hours, and the agreement between this case and other studies such as by Meyer [33] and Martinez-Jeronimo [34] who didn't calculate the LC<sub>50</sub> values until 48 hours later, while LC<sub>50</sub> values were only examined by Park [35] after 24 hours.

Similar study by Barber [36] also demonstrated that the LC<sub>50</sub> values of Cd for *Moina* was 0.35 mg/L.

Baudouin and Scoppa [37] obtained the LC<sub>50</sub> values as 0.055 and 2.50 mg/L after 48 hr. of exposure to *D. lumholtzi hyalina* and *D. lumholtzi rosea*, respectively to Zn concentrations.

Finally, the increase in the mortality percentages with an increase in the ash concentrations may be related to the chemical toxicity which accumulated in the digestive canal and resulted in negative effects such as death [38]. The sensitivity pattern observed during the laboratory exposure to ash metallic may be related to directly accumulated metals in ash by absorption from water. It is possible that the cause of the toxicity that was observed in the current study might have been a result of the accumulation of the toxic components [5].

The current study concluded that the toxicity of ash concentrations has become a great risk with highly adverse effects, especially in the developing countries like Iraq. On the other hand, the acute toxicity exposure on *P. hamulatus* showed harmful effects on all biological aspects of these aquatic food chain organisms.

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